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FEASIBILITY STUDY OF A PRECISION CAST LOADING MACHINE FOR SMALL AMMUNITION ITEMS

Abraham Lerner

Picatinny Arsenal
Dover, New Jersey

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ABRAHAM LERNER

MAY 1975

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PICATINNY ARSENAL

DOVER, NEW JERSEY

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A concept of a mechanized technique to load molten explosive into small ammunition items under controlled conditions has been established.

Concept proveout through explosive loading studies with mock-ups that simulate the process and techniques was substantiated in part.

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ABSTRACT

A concept of a mechanized technique to load molten explosive into small ammunition items under controlled conditions has been established.

Concept proveout through explosive loading studies with mock-ups that simulate the process and techniques was substantiated in part.

I. SUMMARY

This study was undertaken to improve the present state-of-the-art in cast loading of mass produced small ammunition items.

Present manual techniques have been carried out to their highest potential and any significant cost reduction, improvement in quality, consistency and production rates must come from the application of automatic equipment techniques.

A concept of a machine utilizing an injection cell where molten explosive is introduced into the munition item under controlled conditions has been established.

II. CONCLUSIONS

Loading studies with the first generation mock-up confirmed the following features associated with the explosive injection cell concept.

1. Explosive loading of a specific item (BLU 26 Hemispheres) with minimum explosive for risers is feasible, resulting in minimum riser scrap loss.

2. Bond between solidified explosive and item's wall is sufficient to resist pull out of mold and separation of two risers.

3. Surface of solidified explosive does not require machining (this includes also the risers separation surface).

Loading studies with the second generation mock-up were not conclusive. Application of additional process techniques and/or process controls are required to substantiate the feasibility of the explosive injection cell concept.

III. RECOMMENDATIONS

This project is still considered a high risk as the loading studies with the second generation mock-up were inconclusive.

Continuation of loading studies with the second generation mock-up should be carried out to substantiate the feasibility of the explosive injection cell concept.

Based on the results obtained, a determination could be made as to continuation of work with the third generation mock-up.

IV. BACKGROUND

The high volume production of explosive cast small ammunition items such as bomblets and grenades prompted the study of mechanizing the loading process.

The present loading process of such items is largely manual, where molten explosive is poured into funnels placed by hand; risers are broken off by hand and precision surfaces and/or cavities are generally machined into the explosive in secondary operations. Equipment is mostly of the conveyor belt type carrying palletized fixtures.

Application of automatic equipment where mechanization eliminates most of the manual operations, will benefit these high volume production items by reducing cost and hazards and increase rates and quality. Such automatic equipment was envisioned to be within the means of present technology.

The gravity pour and funnel placing method could be replaced by the use of core rods in conjunction with pressure feed and/or vacuum exhaust to produce finished surfaces and cavities requiring no future machining. The machine control of casting parameters such as pressures, temperatures, timing and venting will eliminate operator judgment and promote quality and consistency.

V. STUDY

1. Concepts:

A review of literature and patents related to explosive loading of ammunition items resulted in the formulation of a concept shown in Figure 1.

Means of introducing the explosive into the ammunition items were envisioned as an injection cell(s) at the bottom of a molten explosive reservoir.

The item to be loaded (a hemisphere) is cored and the core opening inserted into an elastomeric check valve C of Figure 1. The torus seal diaphragm A upon being inflated by air will seal the explosive in the cell from the rest of the explosive in the reservoir. Membrane B upon inflation will inject a predetermined amount of explosive into the item. Withdrawal of loaded item from cell will cause the check valve to close and collapsing the diaphragm and membrane will prepare the injection cell for another cycle.

Upon solidification of explosive in the loaded item, the core will be withdrawn, severing the two risers from the loaded item which will require no future machining. The risers will be ejected from the mold and the mold will be ready for reuse.

Mechanization of the operations associated with the item's explosive loading utilizing the injection cell concept is shown in Figure 2.

This sequence of operations is envisioned for an automatic machine where the major station is the explosive loading station. Another mechanization concept is shown in Figure 3. This in-line machine employs pallets and also has the explosive loading station as its major station. A projected cost savings utilizing this machine concept is shown in Appendix A.

2. <u>First Generation Mock-up Loading</u>:

As a representative item to be used for the loading studies the hemisphere of the BLU-26 was choosen.

It was also decided to initiate the loading studies with the explosive Cyclotol 70/30 used in the item instead of the inert simulant. This was done in order to accelerate the determination/exploration of the casting parameters associated with the injection cell concept.

Of immediate interest were the following:

a. Pouring explosive through the relatively small sprue.

b. Flow of explosive within the hemisphere and filling pattern.

c. Shrinkage effects on the cast.

d. Adhesion of explosive upon solidification to the item wall and its ability to withstand withdrawal of core and severance of risers without being extracted itself.

e. Surface quality of solidified explosive and cast quality.

To investigate and substantiate the above, a mock-up was built from the details shown in Figure 4 to comprise the assembled mock-up shown in Figure 5. A fluorocarbon (Teflon-DuPont Reg. T.M.) core or mold is attached to the bottom of a steam heated plate containing a sprue and riser. The hemisphere to be loaded is placed to fit the shoulder of the mold and with the aid of a spacer and jack screw, is held firmly against

this shoulder. When the poured explosive in the item has solidified, the spacer is removed and an outer jack screw is tightened against inner jack screw, causing the down movement of the extraction collar severing the two risers from the explosive in the item and extracting the loaded item from the core. The solidified explosive risers are melted out by activating the steam heated plate.

The weight of the explosive in the hemisphere is .084# ave. and its volume 1.4"3 ave. The weight of the risers is .0068# ave. or about 10% of the conventional riser for this item.

A two and one-half (2½) gallon capacity explosive melting kettle was used for the routine melting of the explosive required in the loading studies with the mock-up.

The molten 70/30 Cyclotol was drawn from the kettle in a paper cup and directly poured into the hemisphere.

A pouring procedure has been established (Appendix B) after an initial experimentation with the temperature parameters. The initial loading results are shown in Appendix C.

The unacceptable density of the cast obtained (minimum specification requirement is 1.65 gm/cc) was attributed to the particular batch of explosive obtained for the loading studies.

Panned chips of the same melt had the same low density and radiographic examination of two loaded hemispheres (Appendix D) indicated items free of cavitation.

As the density problem was not seen to be inherent in the loading process, a larger number of hemispheres was loaded (Appendix E).

Based on these loading studies, it has been concluded that with the proper heating of core and hemisphere, the explosive will adhere to the item and not separate when subjected to a stripping force required to extract the loaded hemisphere from the mold and break off the two risers.

Pouring through the small sprue, filled the hemisphere cavity without clogging and the shrinkage effects were minimal not affecting the explosive in the item. Extraction from the Teflon core was clean and without breakage at corners, resulting in smooth explosive surfaces.

surface separation of risers was below the explosive surface, a condition which does not seem to be detrimental. No problem was foreseen in ejecting the solidified risers from the mold once the entire mold will be made of Teflon.

These results substantiated the process associated with the proposed loading concept and prompted the next step of the loading study. This step will require the introduction of molten explosive under pressure into the item, simulating the method of the proposed concept.

3. Second Generation Mock-Up Loading

To introduce the molten explosive under pressure into the item, a second generation mock-up was built in accordance with the assembly shown in Figure 6.

The hemisphere is secured in a fixture containing a Teflon core (Figure 7) and placed on a spring loaded plate.

Molten explosive is introduced into a steam heated brass cylinder and a Teflon or brass piston under air pressure will inject the molten explosive through a short length rubber hose into the hemisphere. A clamp actuated by an air cylinder can close or open the rubber hose.

Because of unknown aspects of operational safety of the mock-up, it was required to be operated by remote control. Figure 8 shows a piping schematic of the mock-up and the associated equipment. A TV camera was placed near the mock-up and the TV monitor and air control valves were placed in an adjacent bay.

A sequence of operations for the second generation mock-up is given in Appendix F.

The sequence was established after some trial loadings with inert material mostly for gaining experience by the operating personnel in the remote control operation.

The initial loading studies of nine hemispheres were conducted with Cyclotol 70/30. The loading results and inspection report are shown in Appendix G.

Although the density of the casts was within the acceptable limits the casts were unacceptable. Cavities about 3/32" across were situated on the two stepped edges of the cast at the pouring sprue and opposite the pouring sprue; upper cast surface was higher than the flange shoulder of the hemisphere; separation of risers from the cast left protrusions above the upper cast surface.

The high surface of the cast was attributed to improperly securing the hemisphere to the mold. Instead of the hinged lever (anchored on one leg) a plate will bear on the bottom of the hemisphere by tightening nuts on a threaded portion of the three legs.

Ejection of solidified risers from the mold with the aid of a push-out pin was satisfactory. However,it was felt that the sharp corner of the narrow end of the risers tapers was vital for securing the desired separation surface (below the upper explosive surface). The Teflon mold sustained nicks from the rough handling and was dressed up. Also a polished stainless steel mold was fabricated and intended to be used without a mold separation agent.

Upon resumption of loading studies, difficulties were encountered with the Telon piston jamming occasionally in the cylinder. The mock-up was decontaminated and realigned in the shop. The Teflon piston was replaced by a brass piston (consideration was also given to a smaller piston of either materials using an"O" ring).

The cavities on the steps were thought to result from the flow pattern of the molten explosive in the hemisphere and it was decided to vibrate the loaded fixture upon completion of pour. The loading results with the modified components and procedure is given in Appendix H.

All casts obtained were unacceptable. The stainless steel mold was inadequate if only considering the separation from the loaded item and therefore not considered for future use.

The problem of the cavity persisted and it was intended to experiment with a vibrator having a range of higher frequencies. At this point it was decided to abandon the loading studies with the 2nd generation mock-up, as evaluation of the project's fund status in conjunction with the project's milestones showed that not enough funds were left.

The project efforts were developmental in nature, and the original project's milestones could be considered at best as an approximation of a defined engineering plan formulated on data available at that time.

These efforts have been directed at the loading station which is regarded to be the most critical on the envisioned prototype machine. The step by step development work aimed at establishing casting parameters utilizing an injection cell concept, resulted in the fabrication and utilization of two mock-ups.

The final mock-up to be utilized (3rd generation mock-up) would be in principle the prototype's machine loading station. Fabrication and loading studies with the third generation mock-up were therefore sought with the remainder of the project's funds. It was hoped that sufficient data could be gathered to reflect on the final loading station functional elements and on the adequacy of the cast.

4. Third Generation Mock-Up Fabrication

A sketch of the 3rd generation mock-up is shown in Figure 9. The hemisphere holding fixture was fabricated in accordance with assembly shown in Figure 10.

The injection cell and explosive reservoir was fabricated in accordance with the assembly shown in Figure 11 and some of its details shown in Figure 12.

Design of the diaphragms (Figure 13) was concurred in by a vendor who supplied them in three different materials that were considered adequate for the intended service.

Details of a test fixture for simulating the service and service conditions of the shut off diaphragm are shown in Figure 14. It was intended to "pulse" the diaphragm (inflate and deflate) at 10 cycle/min within a restricting collar immersed in boiling water. Initial test results(Appendix I) showed that the fluorosilicone diaphragm did not develop a permanent set at the end of a "working shift". The rupturing and resulting leak was attributed to the sharp edge of the clamping band and could be possibly averted by the use of one of the components shown on Pages 3 and 4 of Figure 14.

APPENDICES

ESTIMATE OF COST SAVINGS

Existing two lines for loading the item, operate at the rate of 5,000 items per hour, and on a 3/8/5 schedule will produce 120,000 items/day or 30,200,000 items/year. Assuming a pallet carrying 20 halves (hemispheres) being processed every 25 seconds or 25 items/min. the envisioned machine (Figure 3) rate would be:

$$24\ (60) = 1{,}440 \text{ items/hr.}$$
$$\frac{5{,}000}{1440} = 4 \text{ machines}$$

The existing two lines employ 20 fuze cavity crilling operators. Each machine will therefore eliminate 5 drilling operators.

Savings for one machine = 5 ($6/hr. DL & OH) (24 hr) (5) (52) = $187,000/yr

Savings for 4 machines replacing the two lines: 4 (187,000) = $748,000/yr.

An undetermined cost saving should result from the reduction of the riser material to approximately 10% of the conventional riser.

Procedure for Loading BLU 26 Hemispheres with 1st Generation Mock-Up

1. Clean inside of hemisphere with an acetone moist cloth.

2. Explosive temperature before pouring should be 195° - 210°F.

3. Steam jacket temperature before pouring should be 200° - 210° F.

4. Hemisphere temperature before pouring should be 150° - 180°F.

5. Pour explosive through one opening and hand shake fixture for explosive to fill hemisphere cavity. Pour explosive in hole to bring explosive level in both holes to below cover gasket level.

6. Shut off steam to steam jacket upon completion of pour.

7. Extract loaded hemisphere after 15 minutes (or more) from time of pouring.

APPENDIX B

Inspection Report

ITEM: Blu-26, 70/30 Cyclotol, (NOL-51-222) January 26, 1970
X.C.: 5045-46-003 (JO 298-69)
REQUESTED BY: Mr. A. Lerner
INSPECTED BY: Mr. [illegible]. Richards
DATE INSPECTED: January 1970

Piece No	Empty Wt (gm)	Loaded Wt (gm)	HE Wt (gm)	Density (gm/cc)
3	152.3172	185.6736	33.3564	1.568
4	152.6843	185.3563	32.6720	1.609
6	153.7324	186.7067	32.9743	1.583
8	152.6270	186.0515	33.4245	1.600

*Panned Chip No	Dry Weight (gm)	Wet Weight (gm)	Basket Wt (gm)	Density (gm/cc)
1	32.39471	12.14317	.28210	1.576
2	54.18459	20.54099	.28210	1.595
3	63.34718	23.96070	.28210	1.595

*Panned Chips obtained from excess cyclotol panned out after loading Blu-26.

ROBERT J. SKETTINI
Ch, Engr & Eval Br

RESULTS OF X-RAY INSPECTION

NOMENCLATURE

Cyclotol Charges (Dia 26)

EX. ORDER	TYPE OF EXPLOSIVE	LOT OR SUBLOT
517?-04-003		

TYPE OF INSPECTION	AMT. IN LOT	AMT. INSP.
R & D ☐ 100% ☐ SAMPLING ☐		2

ITEM NO.	ACCEPTED REJECTED	Items #1 and 2
		Item #1 and 2 - free of cavitation

APPENDIX D

REMARKS

X-rayed for informational purposes.

X-RAYING REQUESTED BY:	VIEWED IN ACCORDANCE WITH:	
Mr. Lerner		
VIEWED BY:	**DATE VIEWED**	**JOB NO.**
F. Kaiser/3429	19 Feb. 1970	1025

SMUPA FORM 1086 FEB. 66

Loading of BLU 26 Hemispheres with the 1st Generation Mock-up

Hemisphere No.	Temp of Steam Jacket Before Pouring (°F)	Temp of Hemisphere Before Pouring (°F)	Temp of Explosive Before Pouring (°F)	Time of End of Pour	Time of Extracting Loaded Hemisphere
11	210	150	200	1445	1505
7	210	150	200	1255	1310
5	210	150	200	1335	1350
12	210	150	200	1025	1045
10	210	150	200	1100	1115
13	210	150	200	1350	1410
15	210	150	200	1420	1440
9	210	152	200	1450	1505
14	210	150	200	1515	1530
17	210	150	200	0855	0910
16	210	150	200	0923	0938
18	210	150	202	0953	1015
20	210	150	200	1029	1045
19	210	150	200	1053	1115
22	210	150	200	1233	1255
21	210	150	200	1300	1320
23	210	150	200	1328	1345
24	210	150	200	1354	1415
25	210	150	198	1420	1440
26	210	150	200	1253	1315
27	210	150	200	1323	1343
28	210	150	200	1350	1410
29	210	150	200	1420	1440

Hemis-phere No.	Temp of Steam Jacket Before Pouring (^{o}F)	Temp of Hemisphere Before Pouring (^{o}F)	Temp of Explosive Before Pouring (^{o}F)	Time of End of Pour	Time of Extracting Loaded Hemisphere
30	210	150	200	1446	1510
31	210	150	200	1024	1044
32	210	150	200	1055	1115
33	210	150	200	1225	1245
34	210	150	200	1258	1319
35	210	150	200	1359	1410
36	210	150	200	1432	1452
38	210	150	200	0803	0823
37	210	150	200	0837	0857
39	210	150	202	0903	0923
40	210	150	200	0930	0950
41	210	150	200	1000	1020
42	210	150	200	1030	1050
43	210	150	200	1058	1118
44	210	150	200	1223	1243
45	210	150	200	1250	1310
46	210	150	200	1314	1334
47	210	150	200	1340	1350
48	210	150	200	1409	1424
49	210	150	200	1434	1454
50	210	150	200	1500	1520
51	210	150	200	0750	0810

Hemis-phere No.	Temp of Steam Jacket Before Pouring (°F)	Temp of Hemisphere Before Pouring (°F)	Temp of Explosive Before Pouring (°F)	Time of End of Pour	Time Extracting Loaded Hemisphere
52	210	160	200	0815	0835
53	210	155	200	0949	0908
54	210	150	200	0916	0936
55	210	155	200	0948	1008
56	210	150	200	1017	1037
57	210	155	200	1043	1103
38	210	150	200	1220	1240
59	210	150	200	1248	1308
60	210	155	200	1320	1340
61	210	150	200	13[illegible]5	1405
62	210	152	200	1415	1435

Inspection Report

ITEM: Blu 26, 70/30 Cyclotol,(HOL-51-222) 17 April 1970
X.O.: 5045-46-003 (JO 298-69)
REQUESTED BY: Mr. A. Lerner
INSPECTED BY: Mr. W. Richards
DATE INSPECTED: April 1970

Piece No	Empty Wt (gm)	Loaded Wt (gm)	HE Wt (gm)	Density (gm/cc)
5	152.4784	185.9478	33.4694	1.562
7	153.3467	186.9982	33.6515	1.581
9	151.8234	184.3902	32.5668	1.522
10	153.5144	185.2636	31.7492	1.518
11	152.5230	185.4352	32.9122	1.558
12	153.5673	184.7305	31.1632	1.481
13	152.3755	185.5432	33.1677	1.527
14	152.5362	185.8662	33.3300	1.538
15	152.7570	185.3240	32.5670	1.533
16	152.3765	186.0050	33.6285	1.574
17	153.3146	186.9818	33.6672	1.556
18	152.6895	186.6458	33.9563	1.568
19	152.6299	187.3246	34.6947	1.584
20	152.3730	186.6135	34.2405	1.577
21	153.5401	186.8858	33.3457	1.551
22	153.7020	187.1860	33.4840	1.541
23	152.8555	185.7981	32.9426	1.539
24	153.8439	187.6459	33.8020	1.564
25	152.5973	183.8749	31.2776	1.457
26	152.8030	186.3005	33.4975	1.563
27	153.3342	185.4132	32.0790	1.500
28	152.2222	184.2075	31.9853	1.459
29	152.8367	184.3937	31.5570	1.468
30	152.5817	180.7825	28.2008	1.415
31	153.1186	188.6092	35.4906	1.642
32	152.6432	187.9850	35.3418	1.623
33	152.6215	185.4466	32.8251	1.520
34	152.6572	187.5195	34.8623	1.631
35	153.3521	185.5386	32.1865	1.493
36	152.6835	183.9613	31.2778	1.505
37	152.6982	185.9410	33.2428	1.538
38	152.7720	185.2655	32.4935	1.496
39	153.5180	185.7040	32.1860	1.484
40	152.3619	183.7747	31.4128	1.474
41	153.1143	182.9454	29.8311	1.418

ITEM: Blu 26, 70/30 Cyclotol, (HOL-51-222) (CONT'D) 17 April 1970

Piece No	Empty Wt (gm)	Loaded Wt (gm)	HE Wt (gm)	Density (gm/cc)
42	153.2573	184.8270	31.5697	1.463
43	152.6614	182.8809	30.2195	1.417
44	152.7605	185.2884	32.5279	1.520
45	152.8637	183.6928	30.8291	1.440
46	152.4180	180.7150	28.2970	1.337
47	152.7308	181.4326	28.7018	1.349
48	153.2722	185.8210	32.5488	1.525
49	152.6376	184.8606	32.2230	1.496
50	153.0511	185.7045	32.6534	1.499
51	152.5531	186.1760	33.6229	1.554
52	153.3632	186.5238	33.1606	1.520
53	152.6179	184.3285	31.7106	1.477
54	152.9082	184.4562	31.5480	1.456
55	153.0325	185.4574	32.4249	1.500
56	153.5446	183.6433	30.0987	1.583
57	152.2077	183.4058	31.1981	1.464
58	153.3940	188.4635	35.0695	1.611
59	153.6180	188.4024	34.7844	1.613
60	153.4436	187.5416	34.0980	1.592
61	152.4186	186.3678	33.9492	1.573
62	152.9112	185.4635	32.5523	1.530

Robert J. Skettini

ROBERT J. SKETTINI
Ch, Engr & Eval Br

Sequence of Operations for 2nd Generation Mock-up:

Initial Conditions:

a. Explosive cut off cylinder is retracted clamping rubber tube shut.

b. Explosive feed cylinder is retracted with teflon plunger about 1" out of the explosive carrying cylinder.

1. Place hemisphere in fixture and place between steam panels for a length of time required to reach desired temperature.

2. Apply steam to explosive holding cylinder (empty of explosive this time) and obtain the stable temperature required. (record temp)

3. Explosive feed air cylinder is in retracted position. Turn handle behind the cylinder and elevate cylinder by sliding in a slot, all the way up.

4. Pour from melt kettle into cup approximately 5 cubic inches of explosive (record temperature of explosive) and pour cup into explosive holding cylinder.

5. Lower explosive feed air cylinder by releasing the slide in the slot and when slide is resting on adjusting screw, lock handle behind the cylinder.

6. Lower manually the teflon plunger until it is about 1" inside the explosive holding cylinder.

7. Place fixture carrying hemisphere on spring loaded table (record hemisphere temperature) and engage end of rubber hose in the recess on the face of the fixture, exposing opposite hole for observation by the TV monitor through the TV camera.

8. Release table so that the fixture is held against the rubber tube by the spring force and lock table by tightening handle on side of table.

9. Go to the mock-up's control area making sure mock-up area is clear of personnel.

10. Move clamping cylinder control lever so that clamp is opened on the rubber tube and at the same time move explosive feed

cylinder control lever so that pressure will be applied to the explosive in the explosive holding cylinder. (record starting time in seconds).

11. Observe the rising explosive in the hole through the TV monitor.

12. As soon as explosive is seen in hole, move explosive feed cylinder control lever to mid position (neutral) and move clamping cylinder control lever to opposite position so that the rubber tube is clamped. (record time in seconds)

13. Enter mock-up area and remove loaded fixture from mock-up by unlocking and depressing table.

14. Clean end of rubber tube from adhering explosive particles and place a second fixture carrying a hemisphere as described in Step 7, and proceed through Step 8 - 13.

15. Establish time required for item to solidify after pouring once and allow some extra time (a few minutes) when loading to insure solid cast when ready to strip from mold. (record time)

16. When attempting to strip item from mold, insert screwdrivers or knives at two opposite ends of items flange and strip with even movement upward (about a $\frac{1}{4}$").

17. With nylon pin, press on risers to eject from mold.

18. Place a pan on the fixture's table, leave mock-up area and move control levers of both cylinders so that most of the explosive in the explosive holding cylinder is ejected into pan.

19. Move explosive feed cylinder control lever so that the teflon plunger is retracted all the way and is about 1" above explosive holding cylinder. Rubber hose is not clamped.

20. Enter mock-up area to remove explosive loaded pan and steam clean plunger and explosive holding cylinder.

Hemis-phere No.	Upper cast surface	Break off of risers: Pouring Sprue	Break off of risers: Riser	Cavity of pouring sprue	Cavity opposite pouring sprue
1	above hemis. flange	above surface	above surface	1st step	2 steps
2	above hemis. flange	above surface	above surface	1st step	2 steps
3	above hemis flange	below surface	above surface	1st step	1st step
4	partially poured				
5	above hemis. flange	above surface	above surface	1st step	1st step
6	above hemis flange	above surface	below surface	2 steps	1st step
7	above hemis. flange	above surface	below surface	1st step	2 steps
8	above hemis. flange	below surface	above surface	1st step	1st step
9	above hemis. flange	below surface	below surface	1st step	2 steps

NOTES:

1. Twelve (12) psi required to move piston in bore ("break away" pressure).
2. 200°F temperature of explosive before pour.
3. 150°F temperature of hemisphere in fixture before pour.
4. 25 psi required to inject explosive (net 13 psi bearing on explosive.
5. 3-4 seconds duration of injection.
6. 20 minutes between injection and stripping of cast hemisphere.
7. 3/32" approximate size of cavities.

INSPECTION REPORT

15 Dec 1970

ITEM : Blu/26, 70/30 Cyclotol, Loaded by Second Generation Mockup
X.O. : 5045-46-003 (J.O. 262-70)
REQUESTED BY : Mr. A. Lerner
INSPECTED BY : Mr. W. Richards
DATE INSPECTED: November 1970

Piece No	Empty Wt (gm)	Loaded Wt (gm)	HE Wt (gm)	Density (gm/cc)
1	153.0887	190.1655	37.0768	1.708
2	154.2710	191.1114	36.8404	1.714
3	153.0832	189.8720	36.7888	1.697
5	153.2540	190.2318	36.9778	1.696
6	155.2000	191.9737	36.7737	1.706
7	155.0657	191.8537	36.7880	1.691
8	155.0545	191.9843	36.9298	1.705
9	153.6646	190.7554	37.0908	1.698

Robert J. Skettini

ROBERT J. SKETTINI
Chief, Engr & Eval Branch

Second Loading of Hemispheres with 2nd Generation Mock-up

Hemisphere No.	Mold Material	Explosive Temp (^{o}F) before pour	Time end of pour	Time extracting loaded hemisphere	Upper cast surface	Hemis. Temp(^{o}F) before pour
2	Teflon	200	9855	1015	above hem. flange	155
3	stainless steel	incomplete pour				150
4	stainless steel	200	1020	1035	even with hemisphere flange	150
5	Teflon	200	1027	1043	even with hemis. flange	150
6	stainless steel	200	1045	1100	even with hemis. flange	150
7	Teflon	200	1050	1105	Even with hemis. flange	140
8	stainless steel	incomplete pour				150
9	Teflon	200	1313	1328	even with hemis flange	150
10	stainless steel	200	1325	1343	even with hemis. flange	150
11	Teflon	200	1335	1350	even with hemis. flange	150
12	stainless steel	200	1352	1407	even with hemis. flange	150

Hemisphere No.	Break off or risers: Pouring sprue	riser	Cavity at pouring sprue	Cavity opposite pouring sprue	Vibrator's air PSI	Vibrator's duration (sec.)	Remarks
2	below surface	below surface	no	no	45	20	Porous around 1st step
3							
4	below surface	cavity	2nd step	no	45	7	chips broken from top surface on extraction
5	below surface	cavity	no	2nd step	45	5	pinhole surface cavities
6	below surface	cavity	2nd step	2nd step	45	5	chips from upper surface
7	above surface	below surface	2nd step	no	45	5	
8							
9	below surface	below surface	2nd step	no	no vibration		porous surface
10	above surface	below surface	2nd step	2nd step	no vibration		sticking to mold (2) 3/8" cavities
11	below surface	below surface & cavity	2nd step	2nd step	45	7	
12	below surface	cavity	2nd step	2nd step	45	7	chips from upper surface

APPENDIX H
Page 2 of 3

NOTES:

1. Net 13 psi bearing on explosive at injection
2. 3-4 seconds duration of injection
3. 3/32" approximate size of cavities
4. Full length vertical cracks in all cast of stainless steel molds.

"Shut Off" Diaphragm Tests in Boiling Water

	Fluorosilicon		Hypalon	
Diaphragm material =	Fluorosilicon		Hypalon	
Diaphragm inflaction pressure =	7 psi		7 psi	
Diaphragm cycling (inflate and deflate	10 cycles/min		10 cycles/min	
	Time	Water temp(^{o}F)	Time	Water temp(^{o}F)
	0830	190	0830	185
	0930	185	0900	195
	1000	205	0930	195
	1030	185	1000	195
	1100	190	1030	195
	1130	195	1100	195
	1200	190	1130	195
	1230	190	1200	190
	1300	190	1230	200
	1330	195	1300	195
	1400	195	1330	195
	1430	195	1400	190
	1500	195	1430	190
	* 1525	185	1500	200
			** 1530	195

* Leak developed along seam (imperfection in diaphragm material at mold joints). In increase in diaphragm outside diameter

** Increase of 1/8" in outside diameter of diaphragm at end of test.

Diaphragm material = Fluorosilicone
Diaphragem inflation pressure = 7 psi
Diaphragm cyc'ing: = 10 cycles/min.

	Time	Water Temp(OF)
	0835	175
	0900	200
	0930	145
	1000	195
	1030	195
	1100	190
	1130	195
	1200	200
	1230	195
	1300	200
	1330	195
*	1333	

* Leak developed at edge of clamp - no increase in diaphragm outside diameter

APPENDIX I
Page 2 of 2

APPENDIX J

PROJECT: PROTOTYPE AUTOMATIC, PRECISION CAST LOADING MACHINE

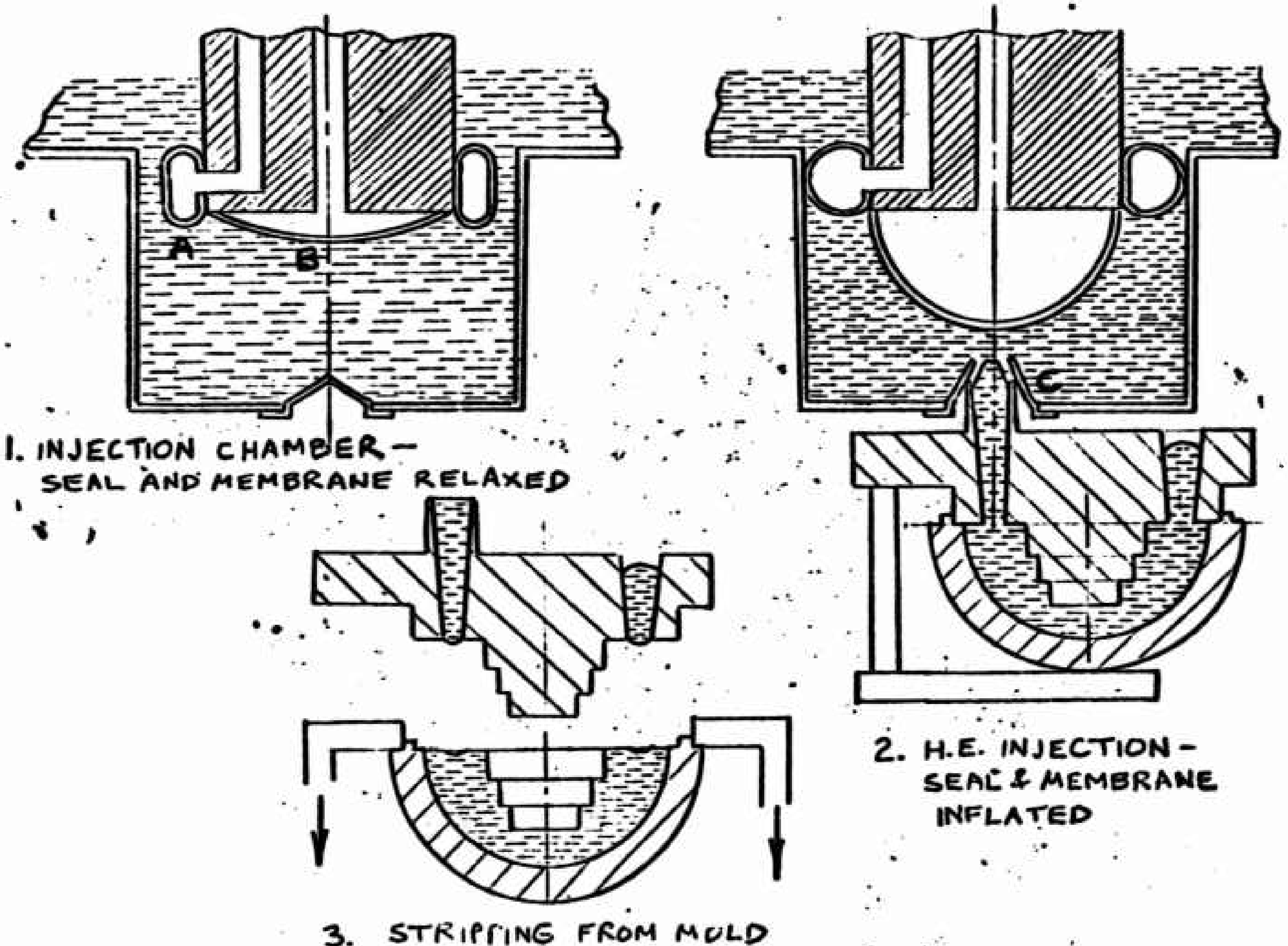
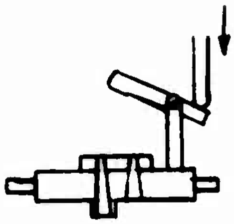
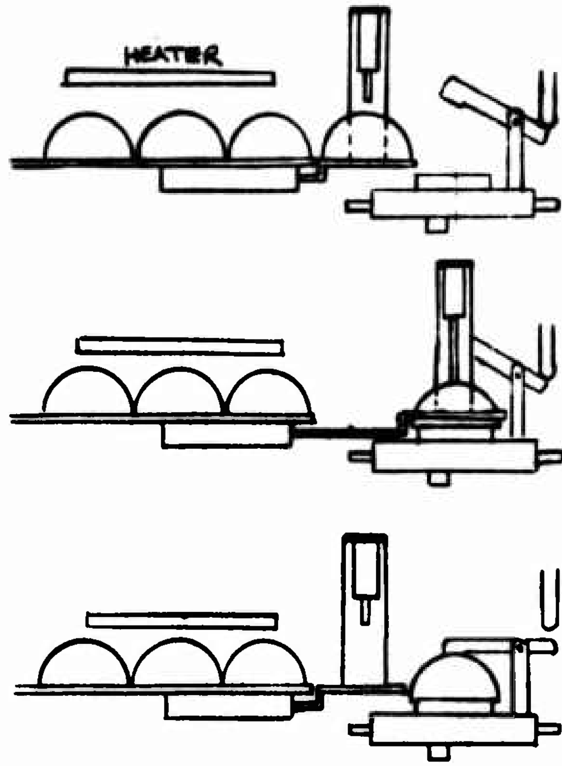


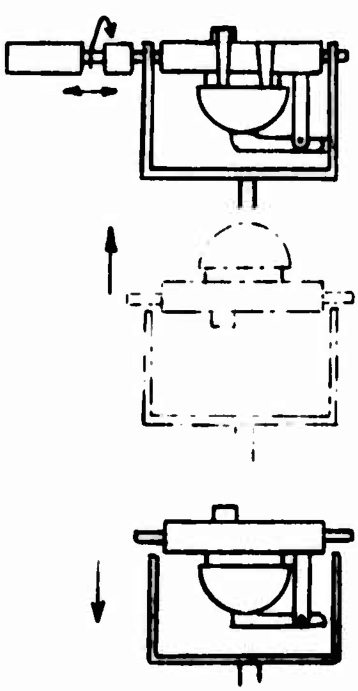
FIGURE 1. INJECTION CELL CONCEPT



STATION 1.

LOAD HEMISPHERE INTO NEST





STATION 2.

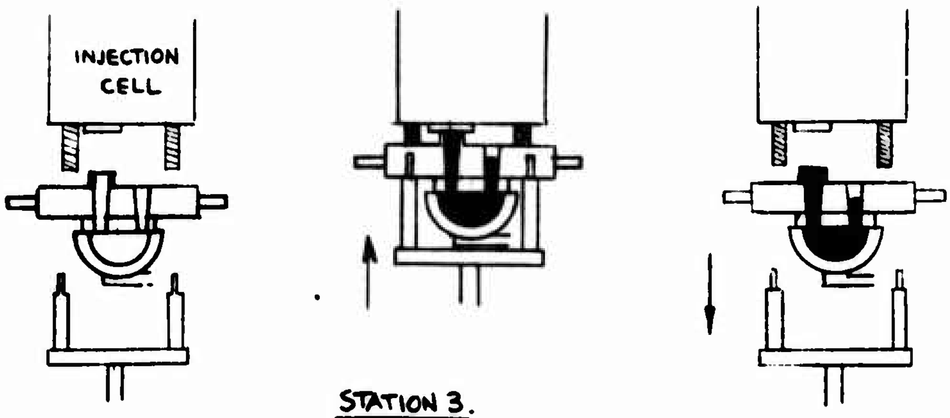
INVERT NEST

FIGURE 2.

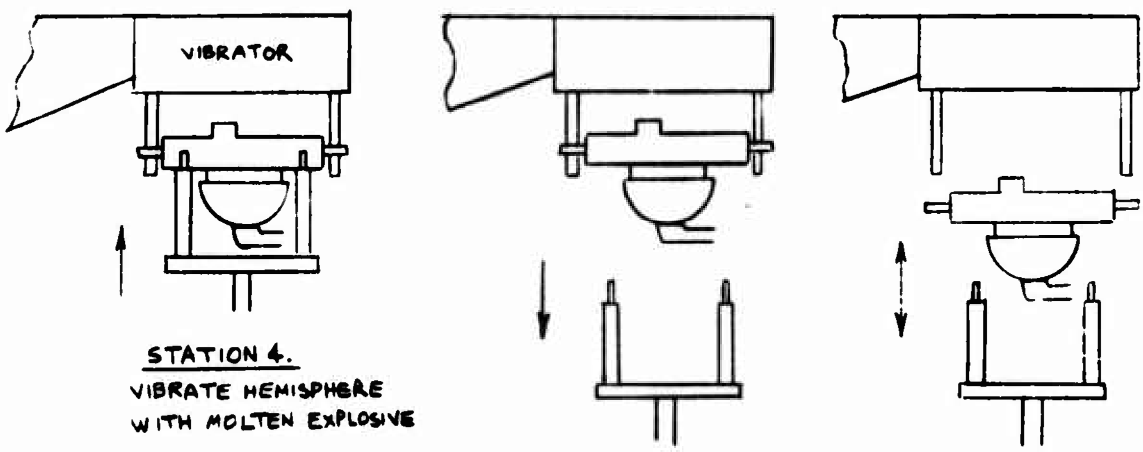
PROPOSED STATIONS OF A CAST LOADING MACHINE & SEQUENCE OF OPERATIONS

RECOMMENDED SEQUENCE OF OPERATIONS FOR A PRECISION CAST LOADING PROTOTYPE MACHINE

SK-87108 PAGE 1 OF 4



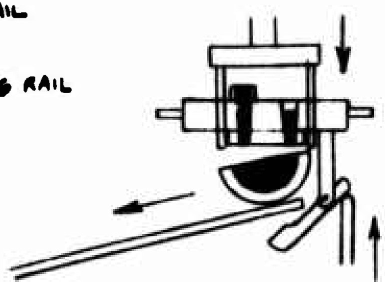
STATION 3.
INJECT EXPLOSIVE
INTO HEMISPHERE



STATION 4.
VIBRATE HEMISPHERE
WITH MOLTEN EXPLOSIVE

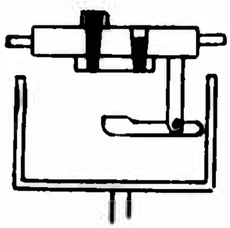
STATION 5.
EXIT TO COOLING RAIL

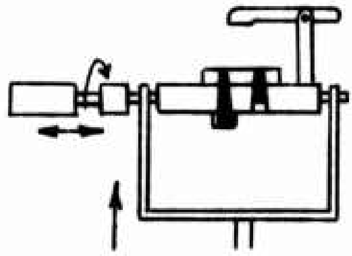
STATION 6.
ENTER FROM COOLING RAIL

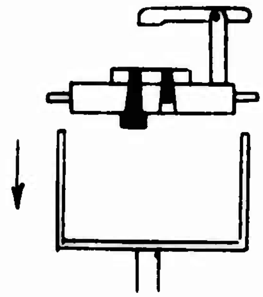


STATION 7.
SEPARATE SOLIDIFIED
ITEM FROM RISERS

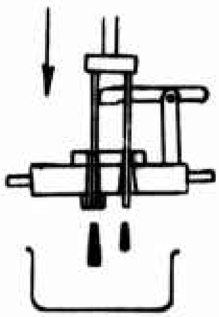
RECOMMENDED SEQUENCE OF
OPERATIONS FOR A PRECISION CAST
PROTOTYPE MACHINE
SK- 87108 PAGE 2 OF 4



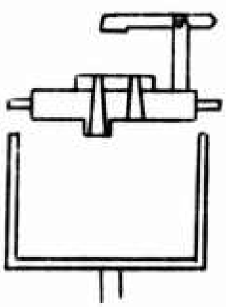


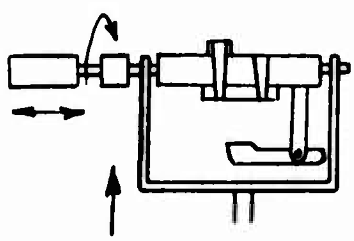


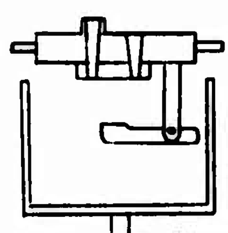
STATION 8.
INVERT NEST



STATION 9.
EJECT RISERS

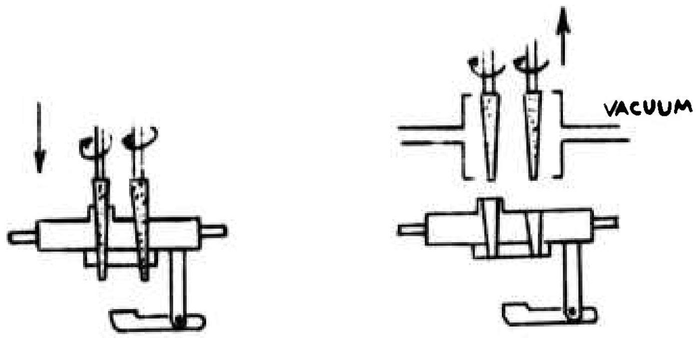




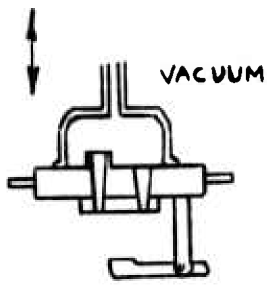


STATION 10.
INVERT NEST

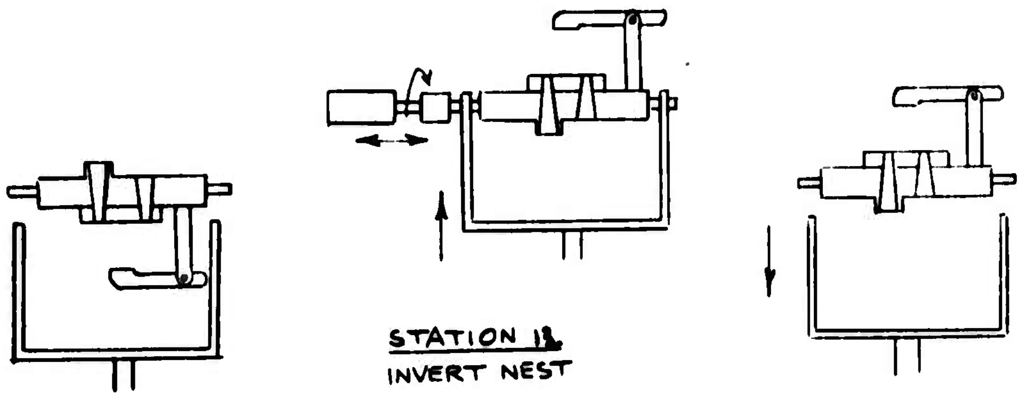
RECOMMENDED SEQUENCE OF OPERATIONS FOR A PRECISION CAST PROTOTYPE MACHINE
SK-87108 PAGE 3 OF 4



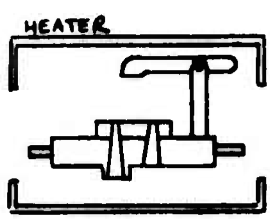
STATION 11.
BRUSH RISER HOLES
& VACUUM BRUSHES



STATION 12.
VACUUM NEST



STATION 13.
INVERT NEST

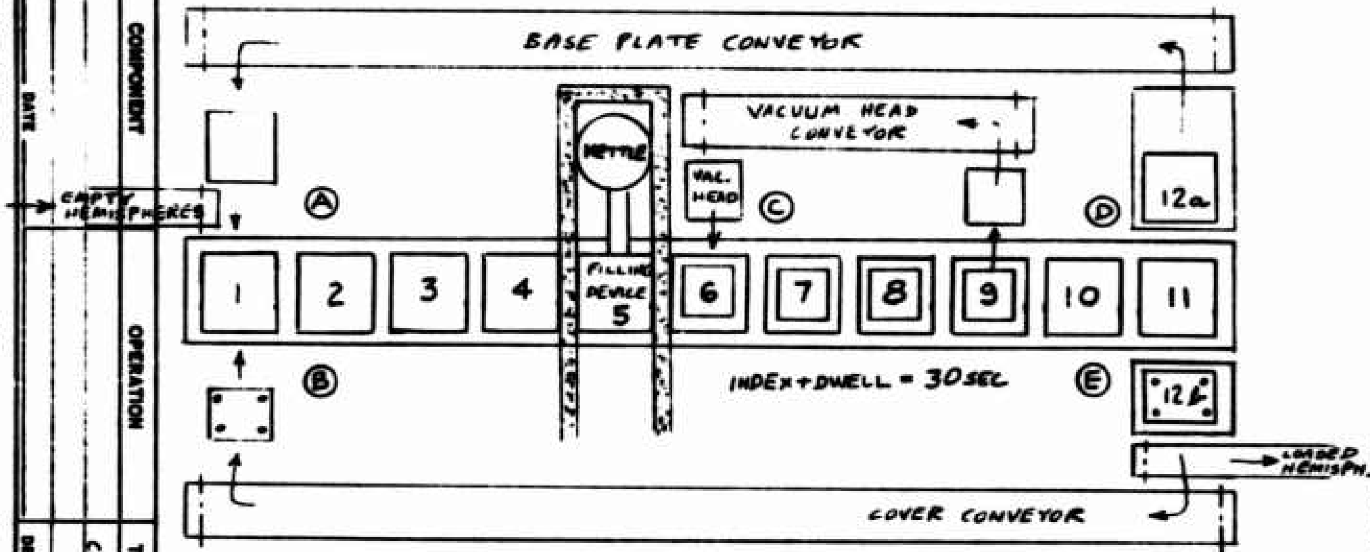


STATION 14.
HEAT NEST

RECOMMENDED SEQUENCE OF
OPERATIONS FOR A PRECISION
CAST PROTOTYPE MACHINE
SK-87108 PAGE 4 OF 4

SMUPA FORM 1233 AUG 66

SKETCH SHEET



SEQUENCE OF OPERATIONS:

1. OPERATOR (A) PLACES BASE PLATE ON CONVEYOR AND LOADS EMPTY HEMISPHERES. OPERATOR (B) PLACES COVER ON BASE PLATE
2. PRESS COVER TO ATTACH TO BASE PLATE
3. INVERT TRAY ASSY.
4. PRESS TO SEAL I.D. OF HEMISPHERES
5. FILL TRAY ASSY
6. OPERATOR (C) PLACES VACUUM HEAD ON TRAY. VACUUM APPLIED.
7 & 8. IDLE STATIONS
9. PICK AND PLACE VACUUM HEAD ON VACUUM HEAD CONVEYOR
10. EJECT COVER AND SEPARATE LOADED HEMISPHERES FROM BASE PLATE
11. OPERATOR (D) REMOVES BASE PLATE TO 12 a. OPERATOR (E) REMOVES COVER & HEMISPHERES TO 12 b.

12a. OPERATOR (D) INVERTS BASE PLATE AND EJECTS EXPLOSIVE PLUGS. VACUUM BASE PLATE AND PLACE ON BASE PLATE CONVEYOR

12b. OPERATOR (E) PLACES LOADED HEMISPHERES ON CONVEYOR. VACUUM COVER AND PLACE ON COVER CONVEYOR.

FIGURE 3.

CONCEPT OF A CAST LOADING MACHINE

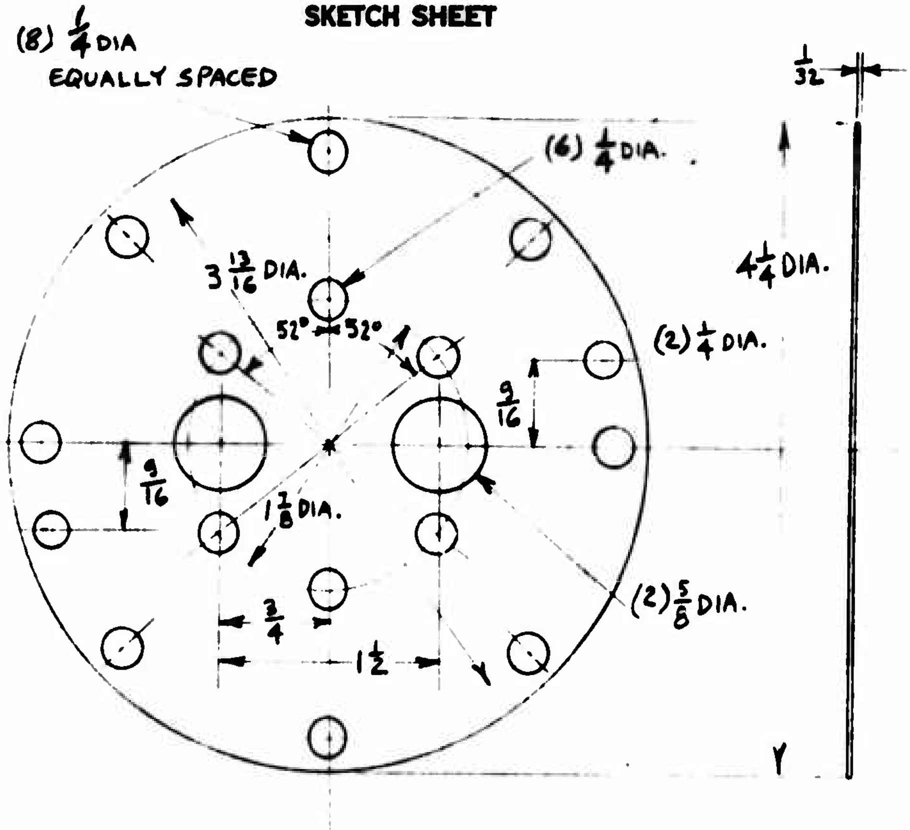
COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY
		CAST LOADING EQUIP.	APPROVED
DWG. ______ DATE ______		DWG. A.L. DATE 1 AUG 69	
INCORPORATED ON DWG. ______ DATE ______ BY ______			DATE

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF ______ SECT. MUST BE RETURNED TO ______ WHEN WORK IS COMPLETED

SK

SHUPA FORM 1210 AUG 66

SKETCH SHEET



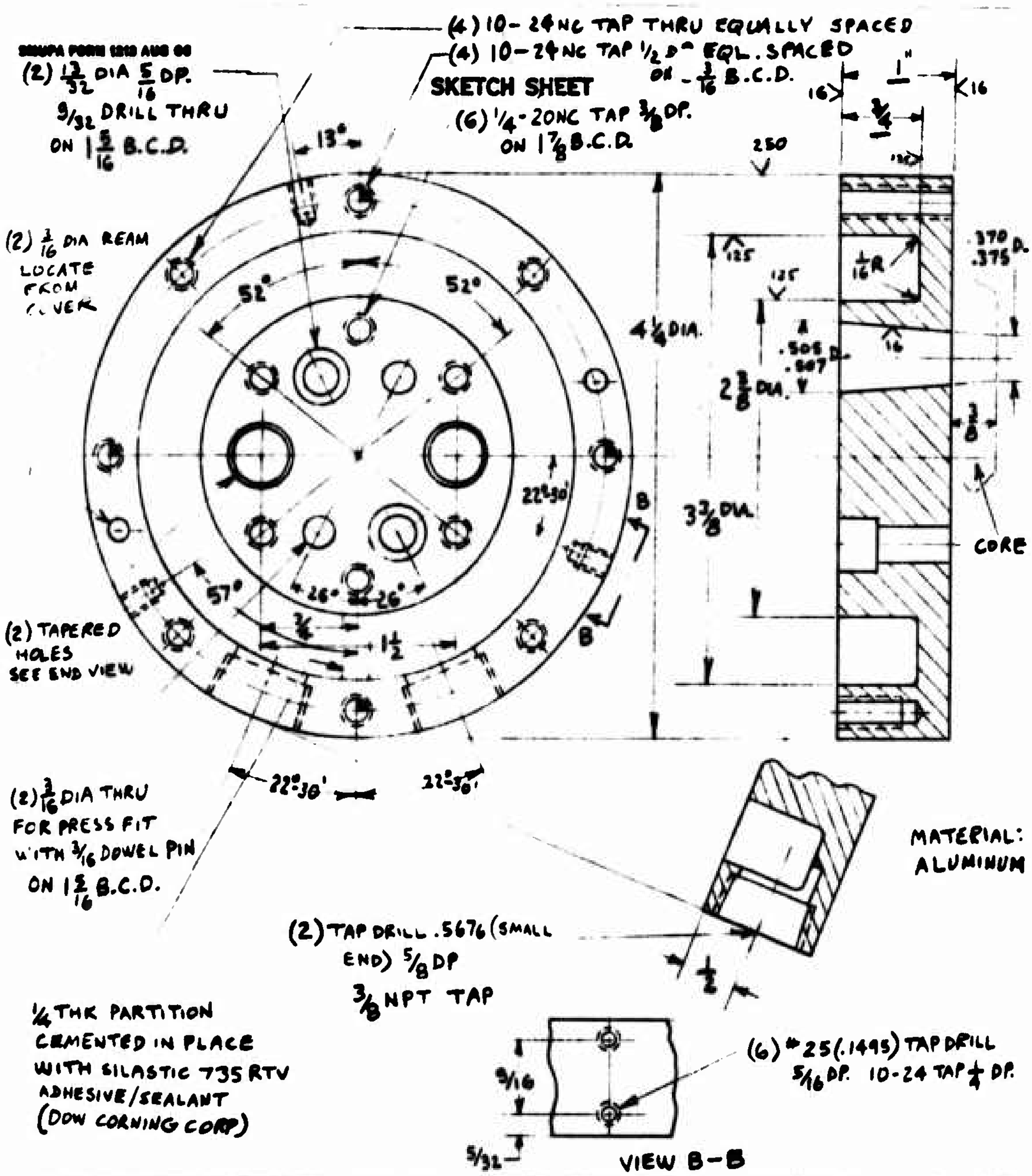
MATERIAL: NEOPRENE

FIGURE 4.
DETAILS OF 1ST GENERATION MOCK-UP

COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY
		LOADING DEVICE	APPROVED
		PAGE 1 OF 9	
DRG. DATE		DRG. A.L. DATE 1 OCT 69	
INCORPORATED ON DRG. DATE BY			DATE

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF SECT. MUST BE RETURNED TO WHEN WORK IS COMPLETED

SK



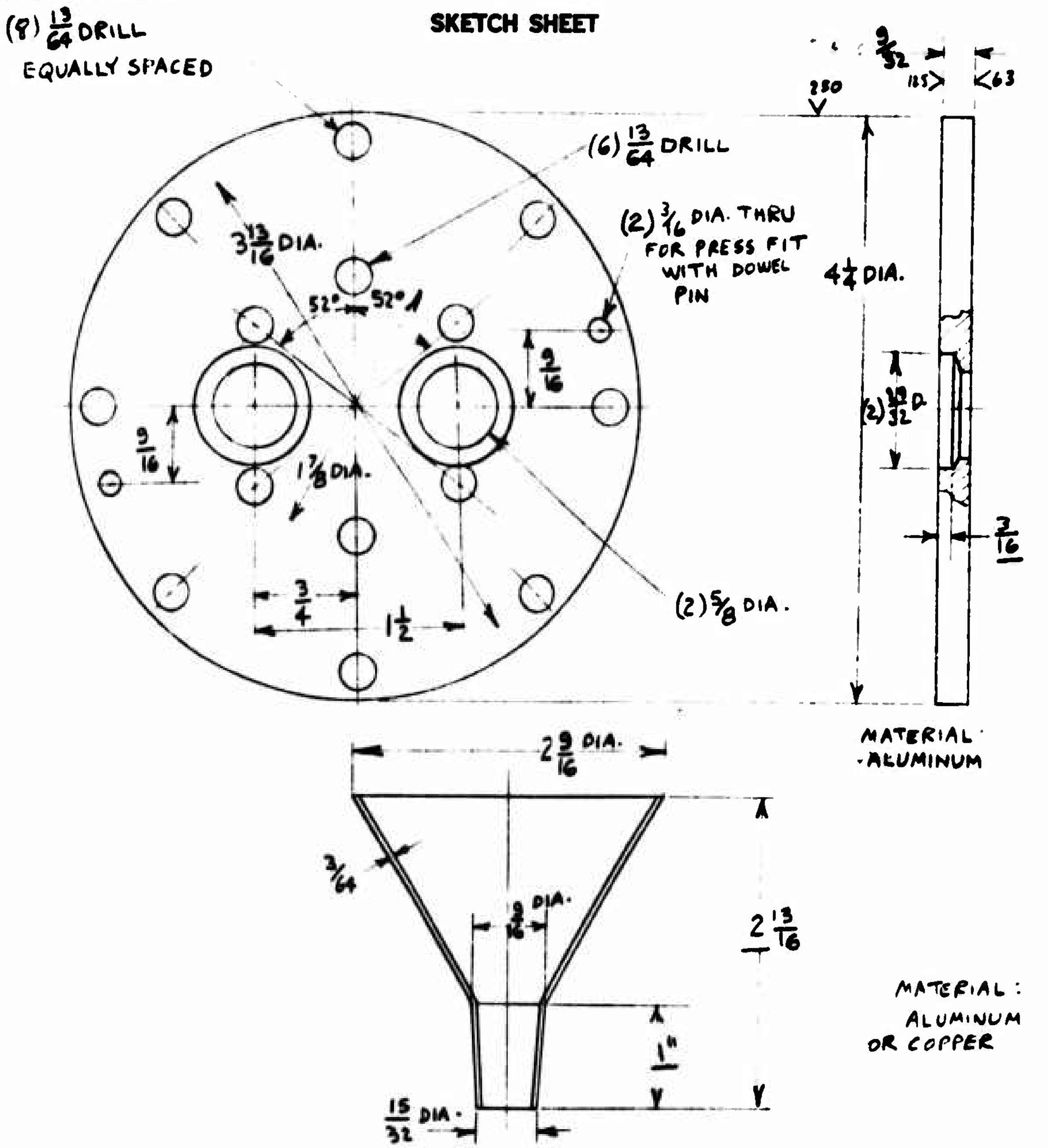
COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	
		LOADING DEVICE	MADE BY
		PAGE 2 OF 9	APPROVED
DRG. DATE		DRG. A.L. DATE 29 SEP 69	

INCORPORATED ON DRG. DATE BY — DATE

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF SECT. MUST BE RETURNED TO WHEN WORK IS COMPLETED — SK

SNUPA FORM 1213 AUG 66

SKETCH SHEET



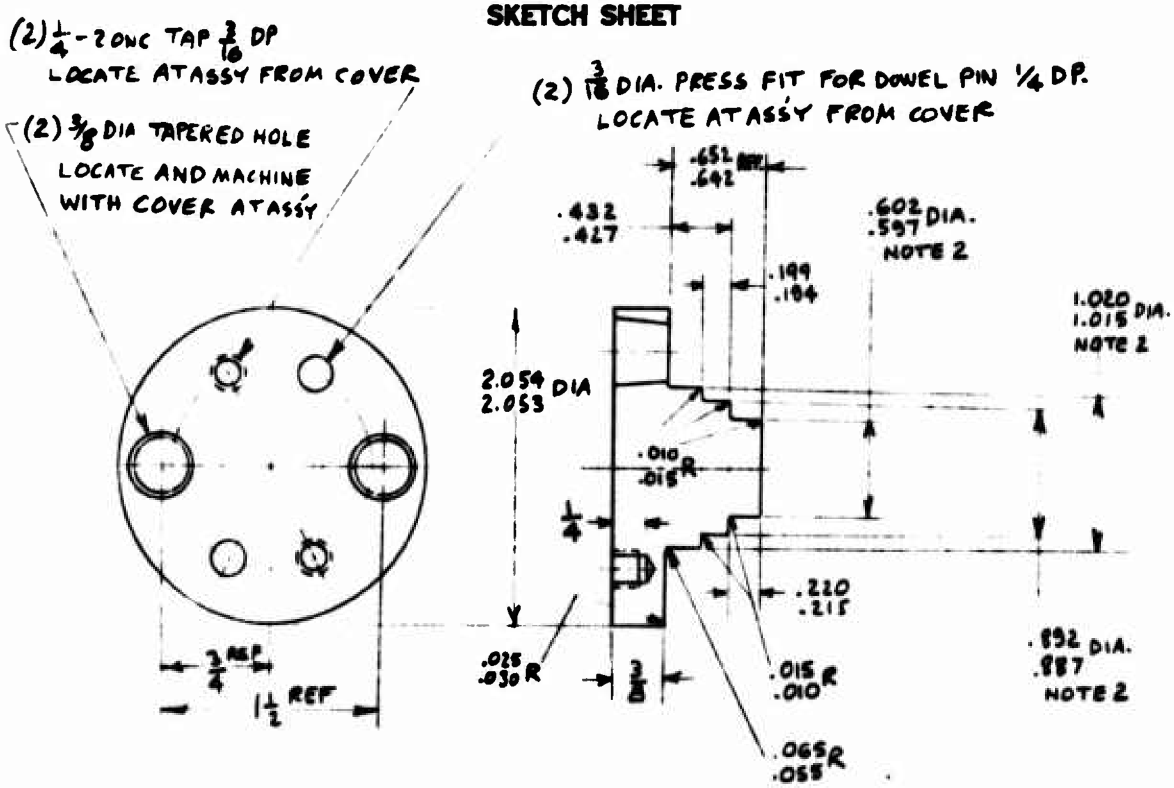
COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY
		LOADING DEVICE	APPROVED
		PAGE 3 OF 9	
DRG. DATE		DRG. A.L. DATE 29SEP64	
INCORPORATED ON DRG. DATE BY			DATE

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF SECT.
MUST BE RETURNED TO WHEN WORK IS COMPLETED

SK

SMUPA FORM 1219 AUG 66

SKETCH SHEET



NOTES:

1. POLISHED SURFACE ALL OVER
2. MACHINE DIAMETERS IN ONE SETTING. ONLY POSITIVE TAPER (FOR MOLD EXTRACTION) PERMITTED WITHIN DIA. TOLERANCES
3. MATERIAL: TEFLON

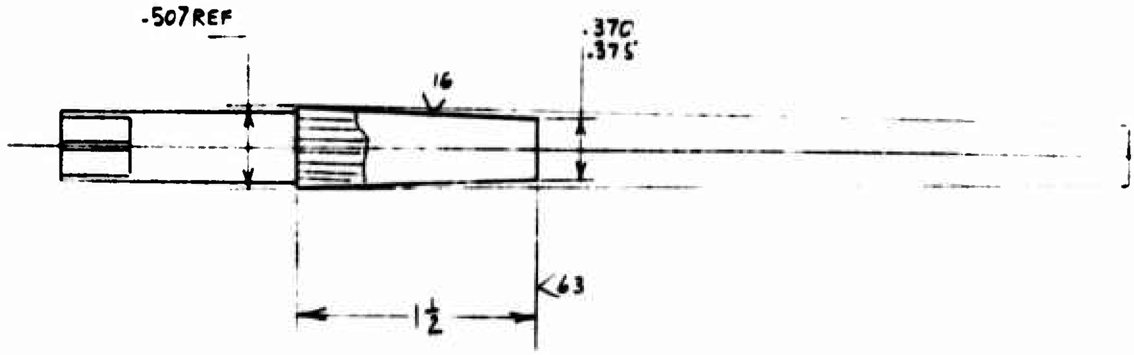
COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY
		LOADING DEVICE	APPROVED
		PAGE 4 OF 9	
DRG. DATE		DRG. A.L. DATE 29 SEP 69	

INCORPORATED ON DRG. DATE BY — DATE

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF SECT. MUST BE RETURNED TO WHEN WORK IS COMPLETED — SK

SMUPA FORM 1213 AUG 66

SKETCH SHEET



COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY ________
		MODIFICATION OF	APPROVED ________
		TAPERED REAMER # 8	
DRG. ________ DATE ________		DRG. A.L. DATE 1 DEC 69	

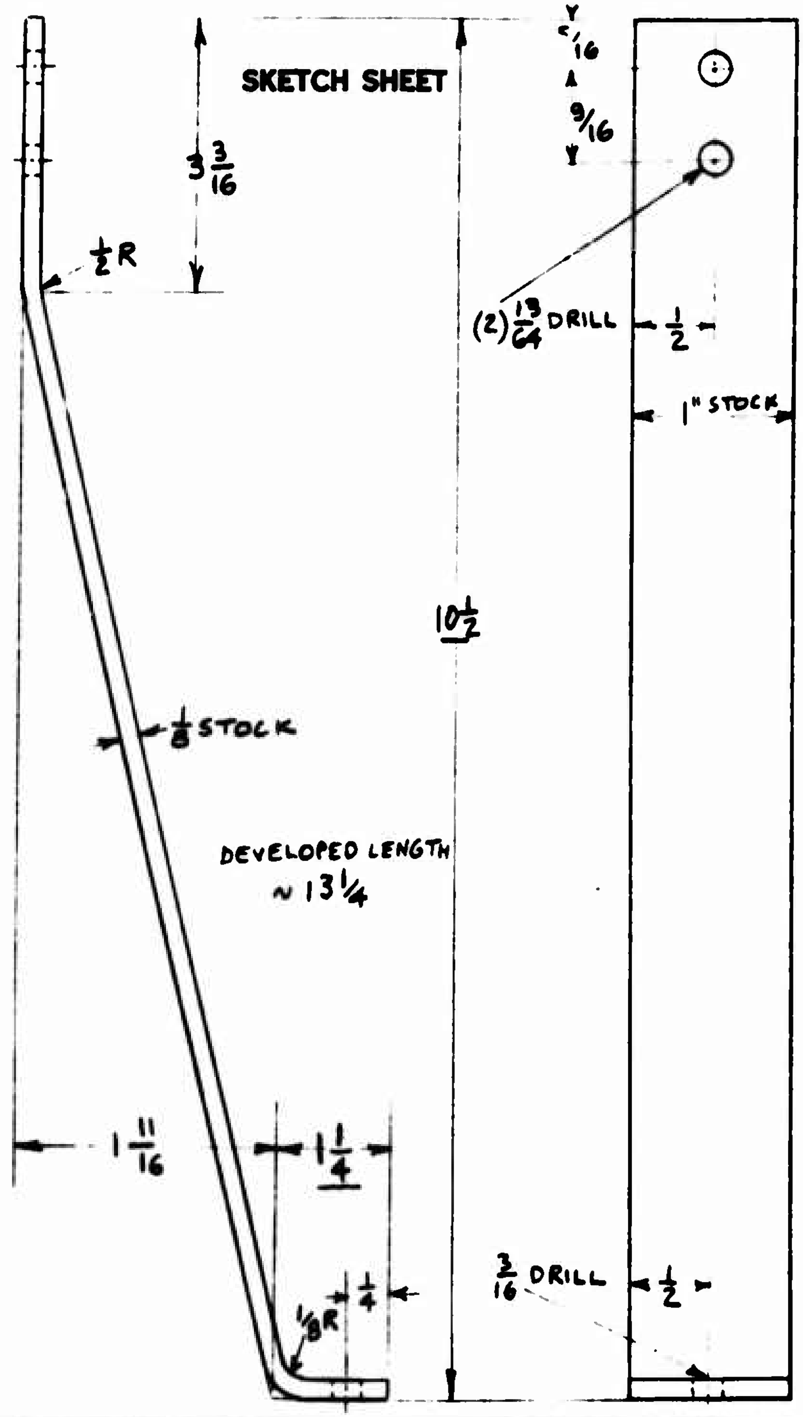
INCORPORATED ON DRG. ________ DATE ________ BY ________ PAGE 5 OF 9 — DATE

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF ________ SECT.
MUST BE RETURNED TO ________ WHEN WORK IS COMPLETED

SK

SMUPA FORM 1213 AUG 66

SKETCH SHEET



MATERIAL:
AISI C-1018
(3) REQ.

COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.
		LOADING DEVICE
		PAGE 6 OF 9
DRG. ______ DATE ______		DRG. A.L. DATE 29 SEP 69

MADE BY ______
APPROVED ______
DATE

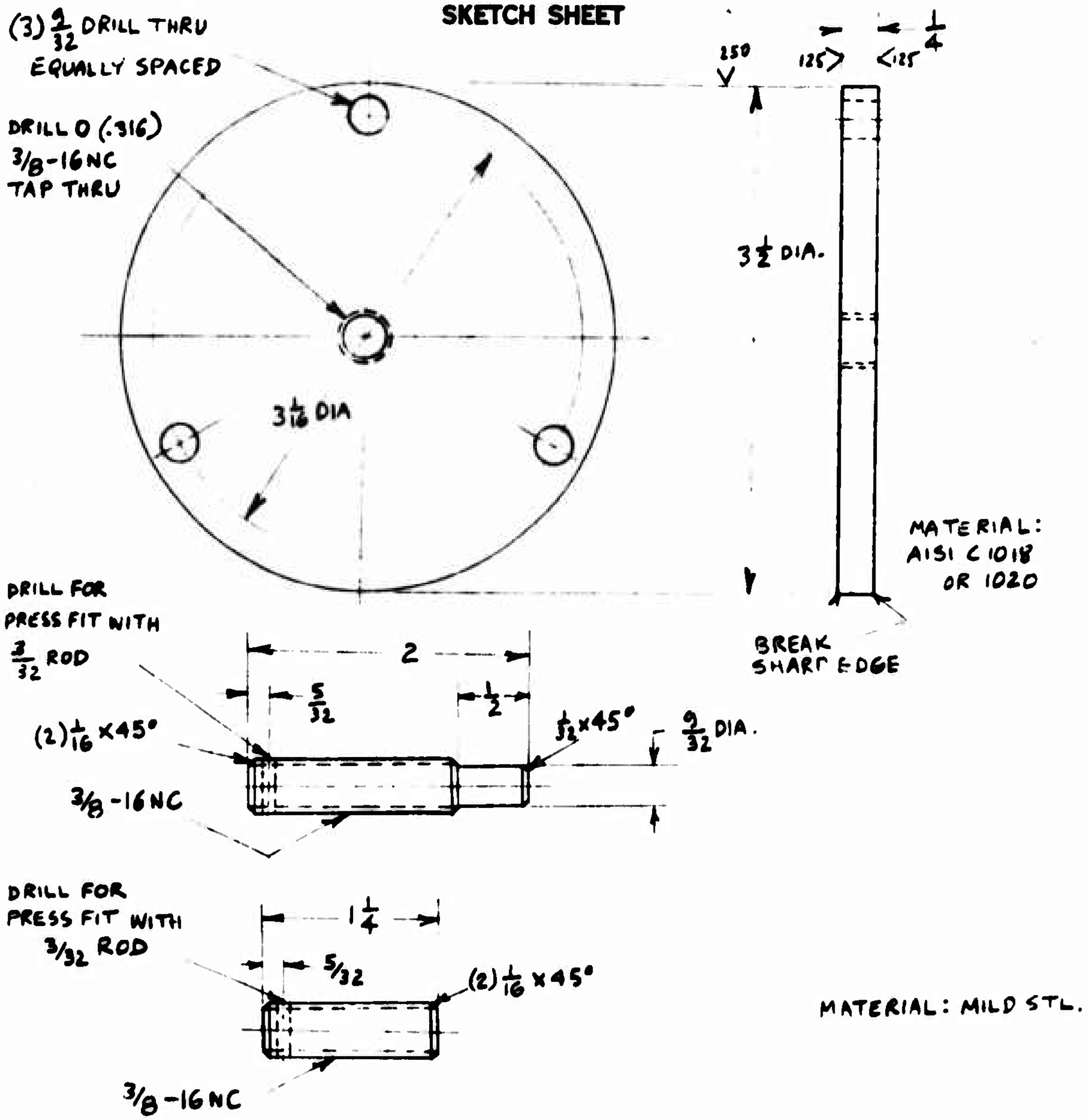
INCORPORATED ON DRG. ______ DATE ______ BY ______

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF ______ SECT.
MUST BE RETURNED TO ______ WHEN WORK IS COMPLETED

SK

SMUPA FORM 1213 AUG 64

SKETCH SHEET



COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY
		LOADING DEVICE	APPROVED
		PAGE 7 OF 9	
DRG. ______ DATE ______		DRG. A.L. DATE 29 SEP 69	

INCORPORATED ON DRG. ______ DATE ______ BY ______ DATE

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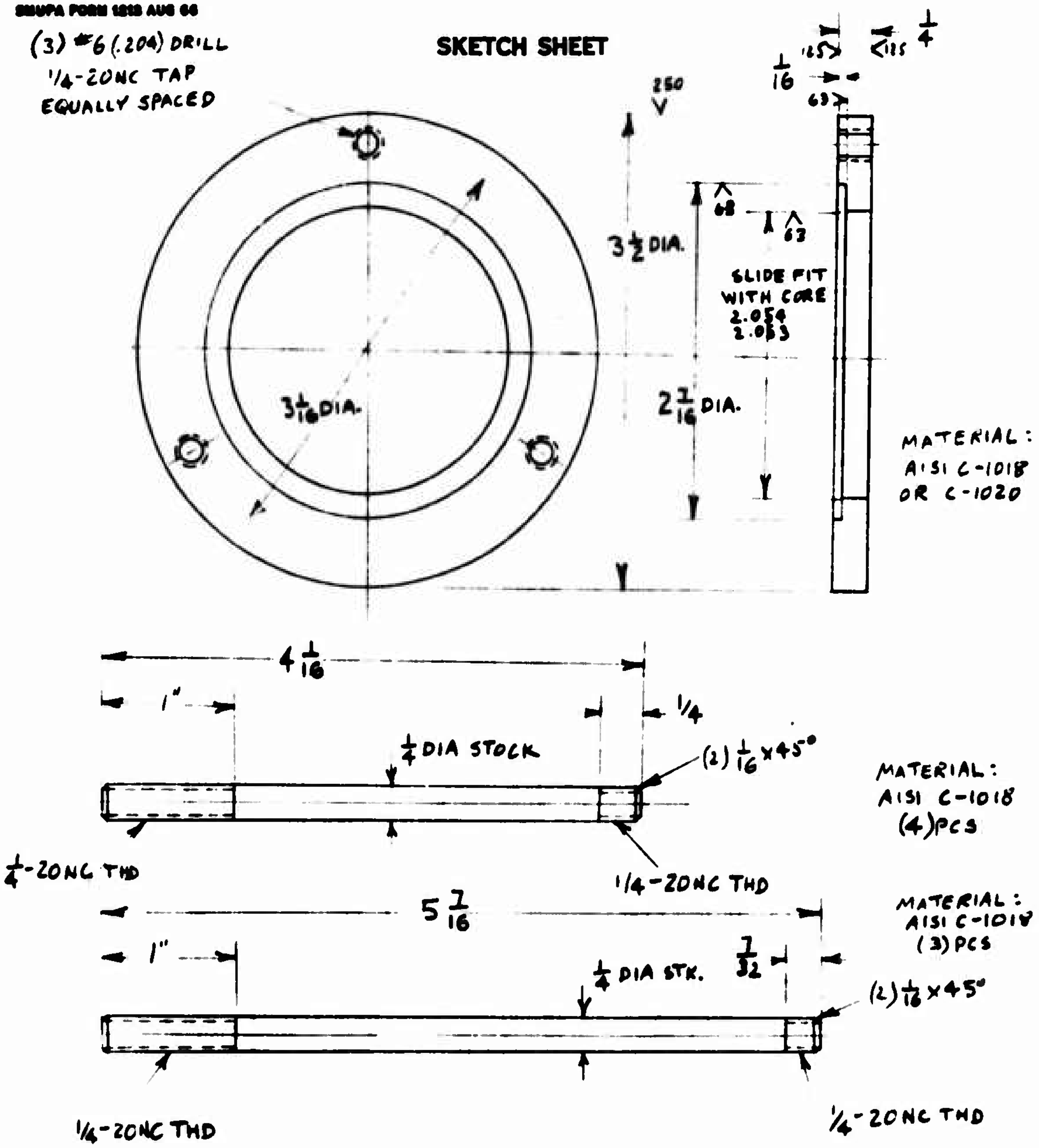
MUST BE RETURNED TO WHEN WORK IS COMPLETED

SK

SMUPA FORM 1213 AUG 66

SKETCH SHEET



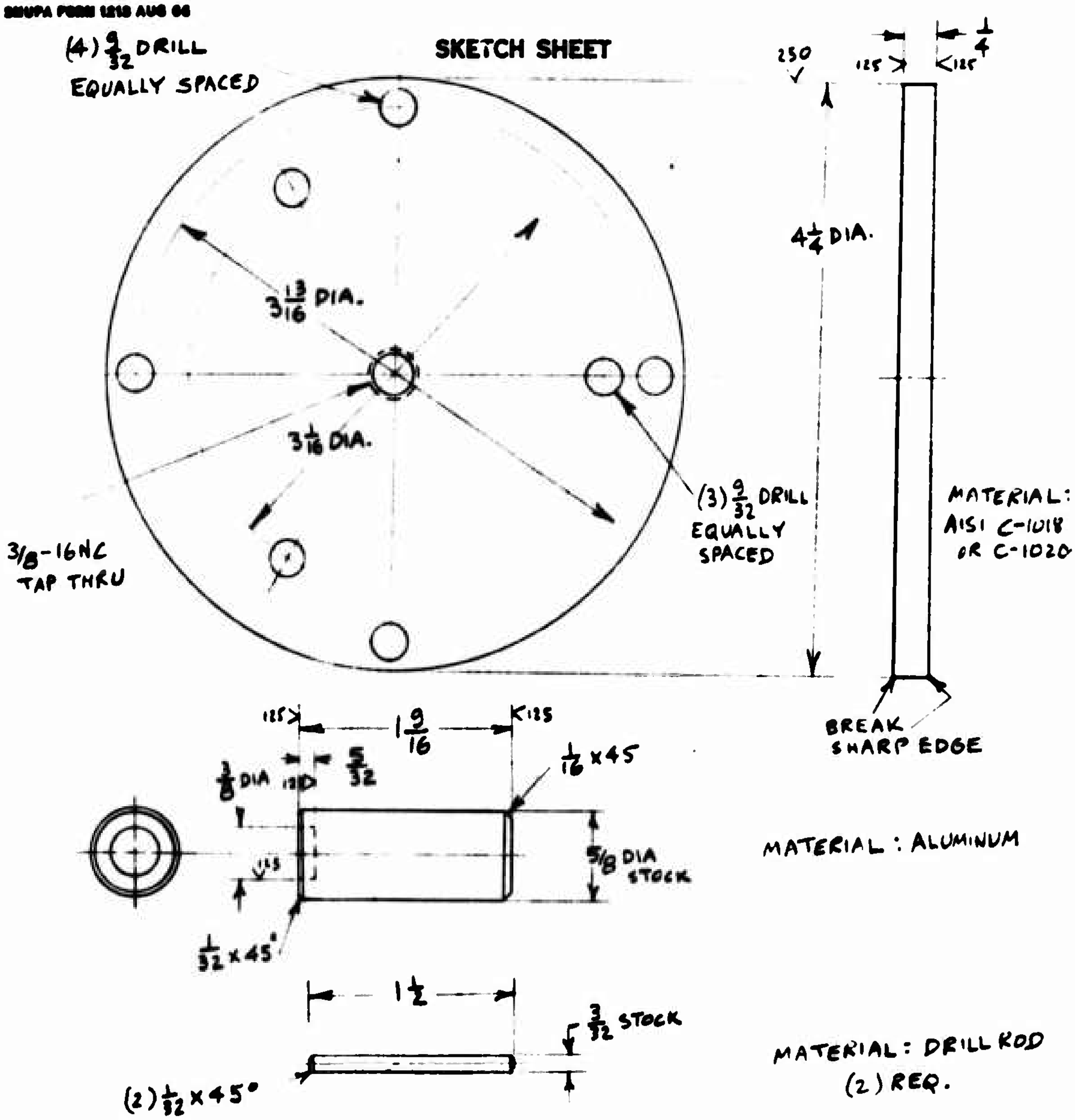
COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY
		LOADING DEVICE	APPROVED
		PAGE 8 OF 9	
DRG. ______ DATE ______		DRG. A.L. DATE 29 SEP 69	

INCORPORATED ON DRG. ______ DATE ______ BY ______ | DATE

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF ______ SECT. MUST BE RETURNED TO ______ WHEN WORK IS COMPLETED | SK

SMUPA FORM 1219 AUG 66

SKETCH SHEET



COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY
		LOADING DEVICE	APPROVED
		PAGE 9 OF 9	
DRG. DATE		DRG. A.L. DATE 29 SEP 69	
INCORPORATED ON DRG. DATE BY			DATE
NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF SECT. MUST BE RETURNED TO WHEN WORK IS COMPLETED			SK

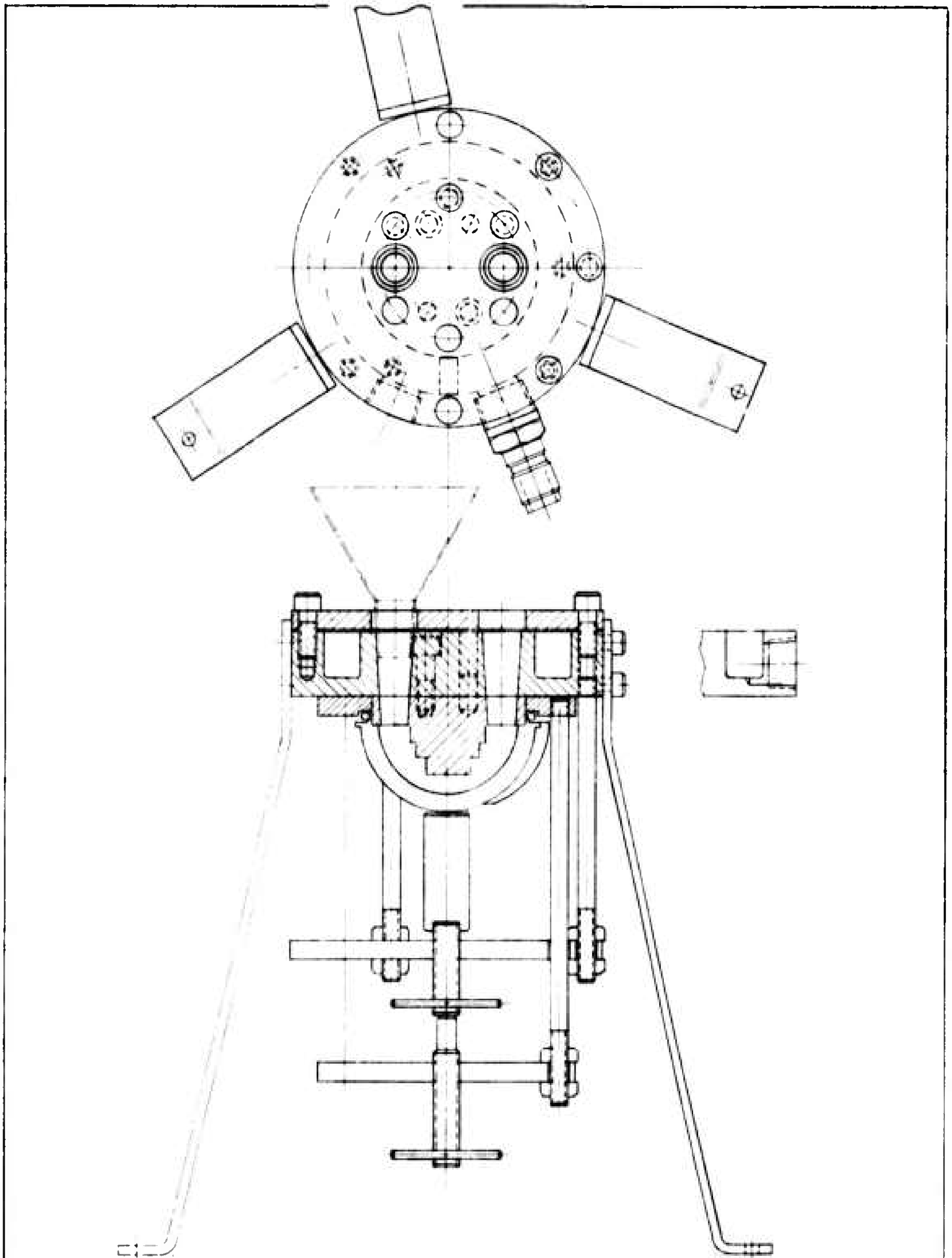
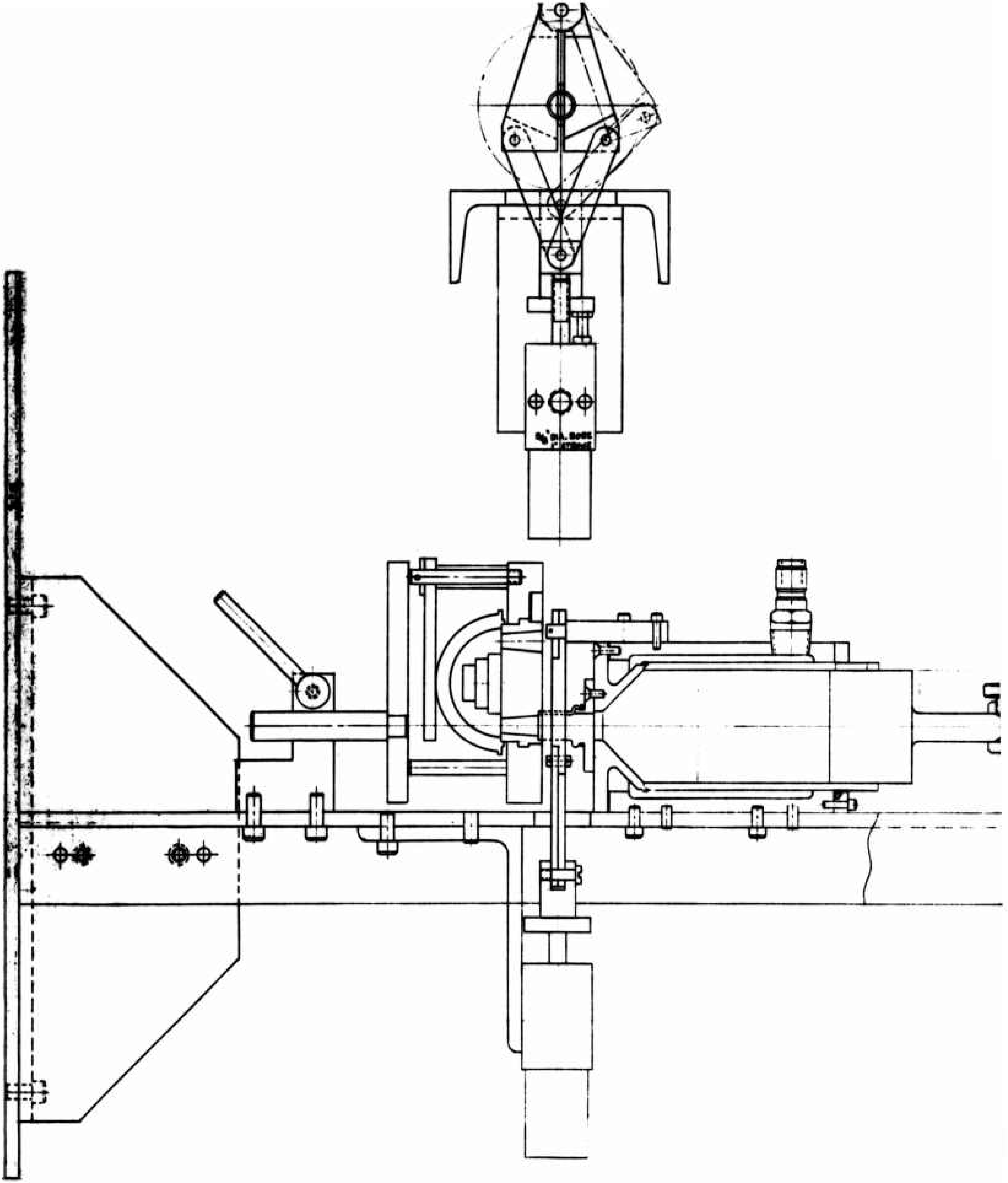
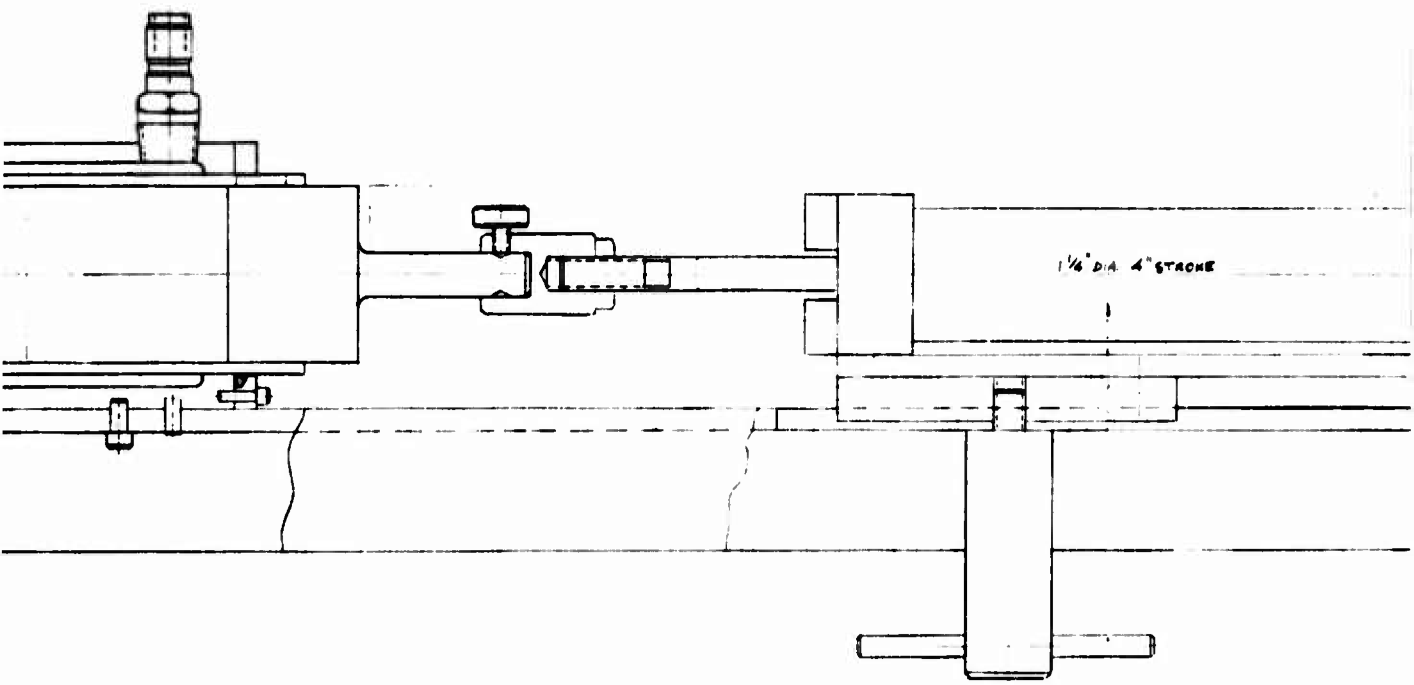


FIGURE 5

EXPERIMENTAL LOADING DEVICE
FOR BLU/26 BLU/36


DIA. BORE


1 1/4" DIA. 4" STROKE

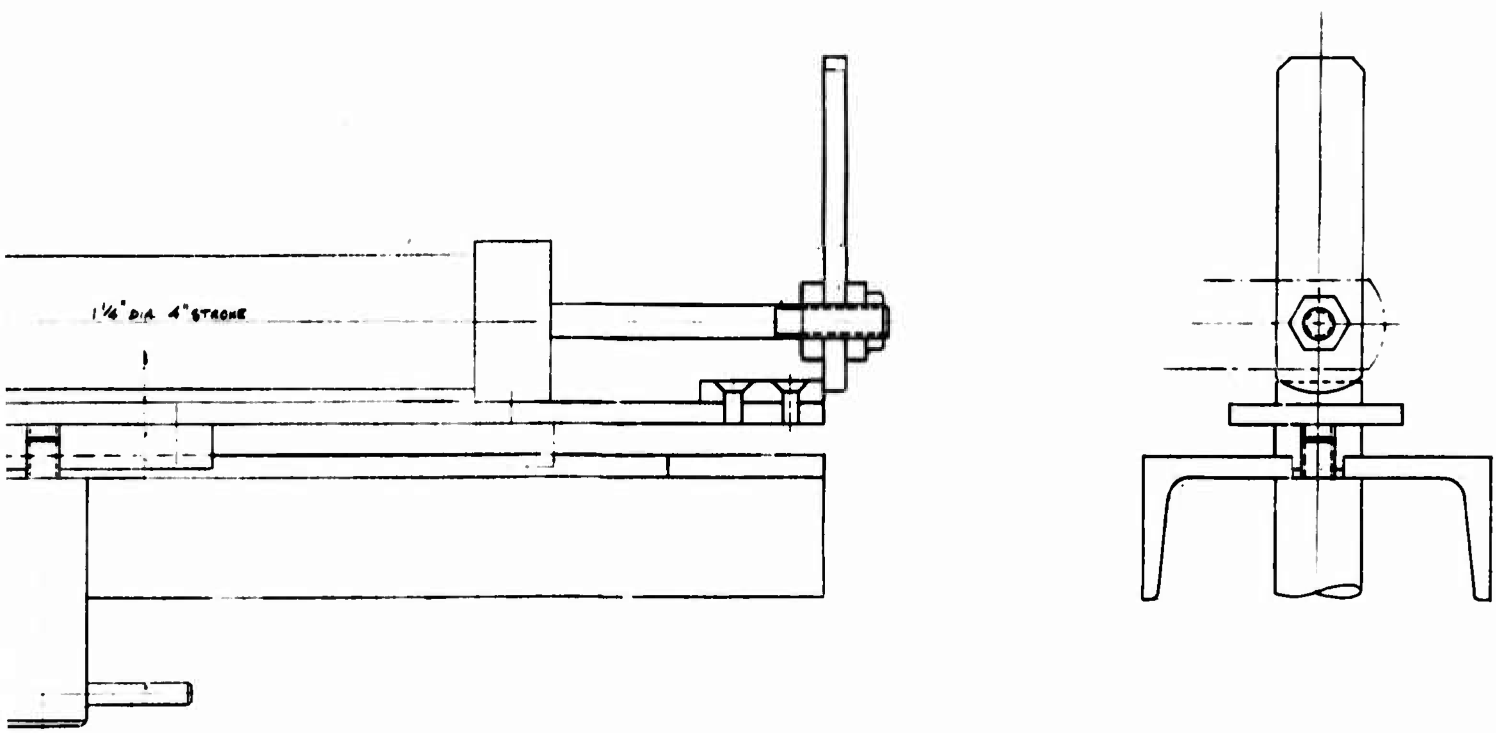
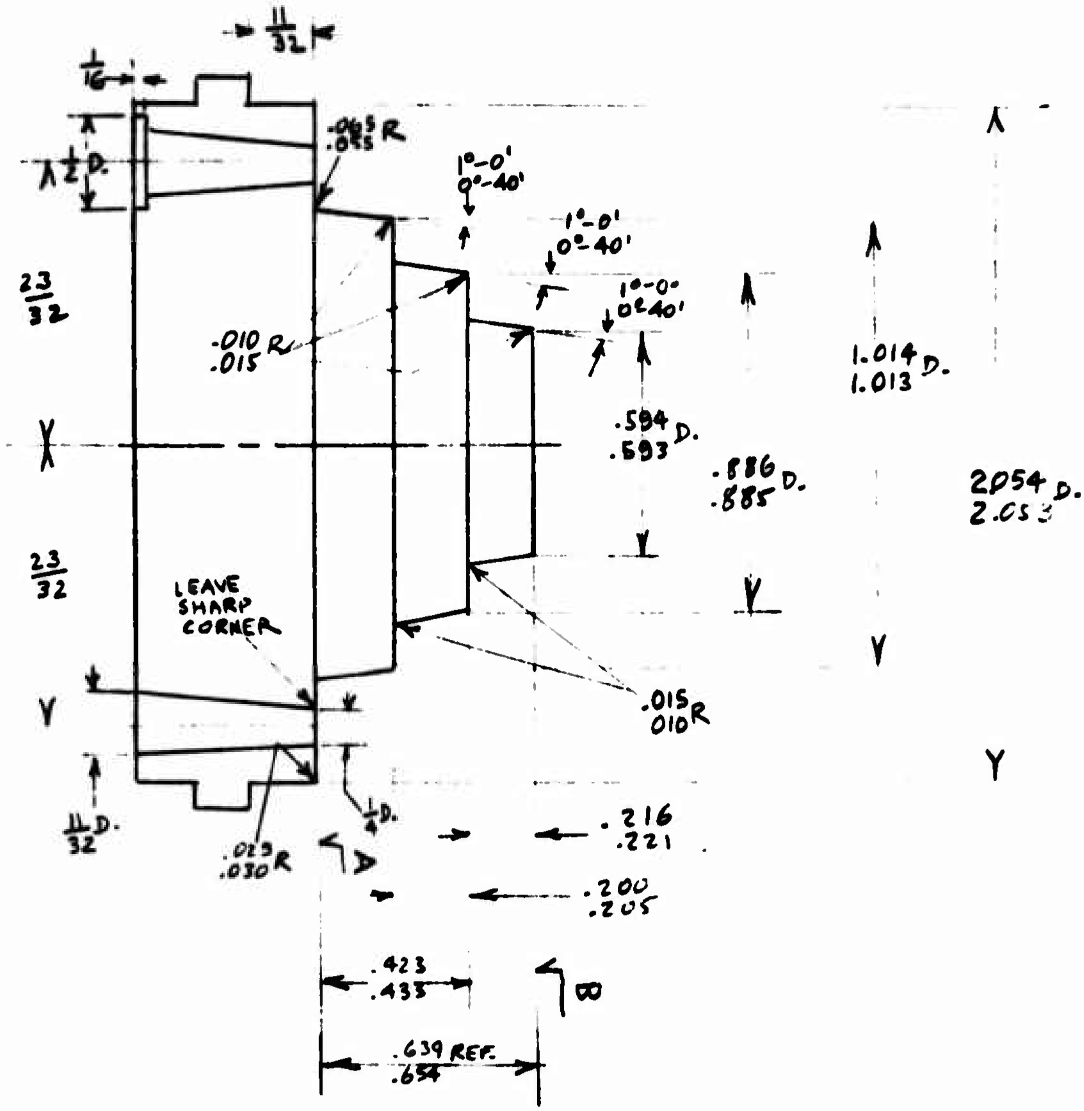


FIGURE 6.

EXPERIMENTAL LOADING DEVICE (2nd GENERATION)
FOR BLU/26 BLU/36 A.L. 4MAR70 SK 87099



NOTES:

1. MATERIAL: STAINLESS STL

2. ALL DIMENSIONED DIA. TO BE MACHINED IN ONE SETTING. UNDIMENSIONED FEATURES TO FIT EXISTING HOLDER.

3. ALL SURFACES BETWEEN SURFACE A AND B (ALSO A & B) INCLUDING TAPPERED HOLES, TO BE POLISHED.

CORE DETAIL OF 2ND GEN. MOCK-UP

FIGURE 7

SKETCH SHEET

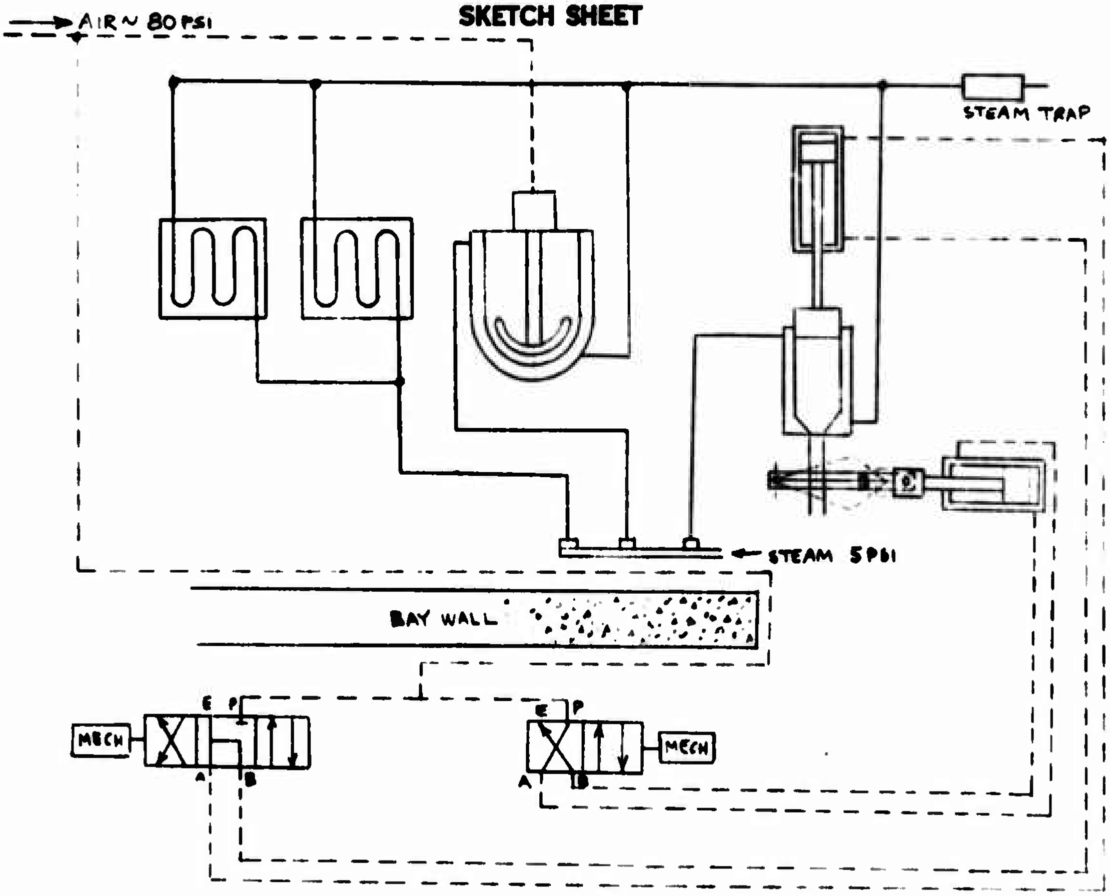


FIGURE 8.
PIPING SCHEMATIC FOR 2ND GENERATION MOCK-UP

COMPONENT	OPERATION	TOOL - JIG - FIXTURE - MACH.	MADE BY
		PIPING SCHEMATIC FOR	APPROVED
		EXP. LOADING FIXTURE	
DRG. DATE		DRG. A.L. DATE 21 JUL 70	
INCORPORATED ON DRG.	DATE	BY	DATE

NOTE:—THIS SKETCH MAY BE USED BY SHOPS ONLY IF APPROVED BY REPRESENTATIVE OF SECT.
MUST BE RETURNED TO WHEN WORK IS COMPLETED

SK

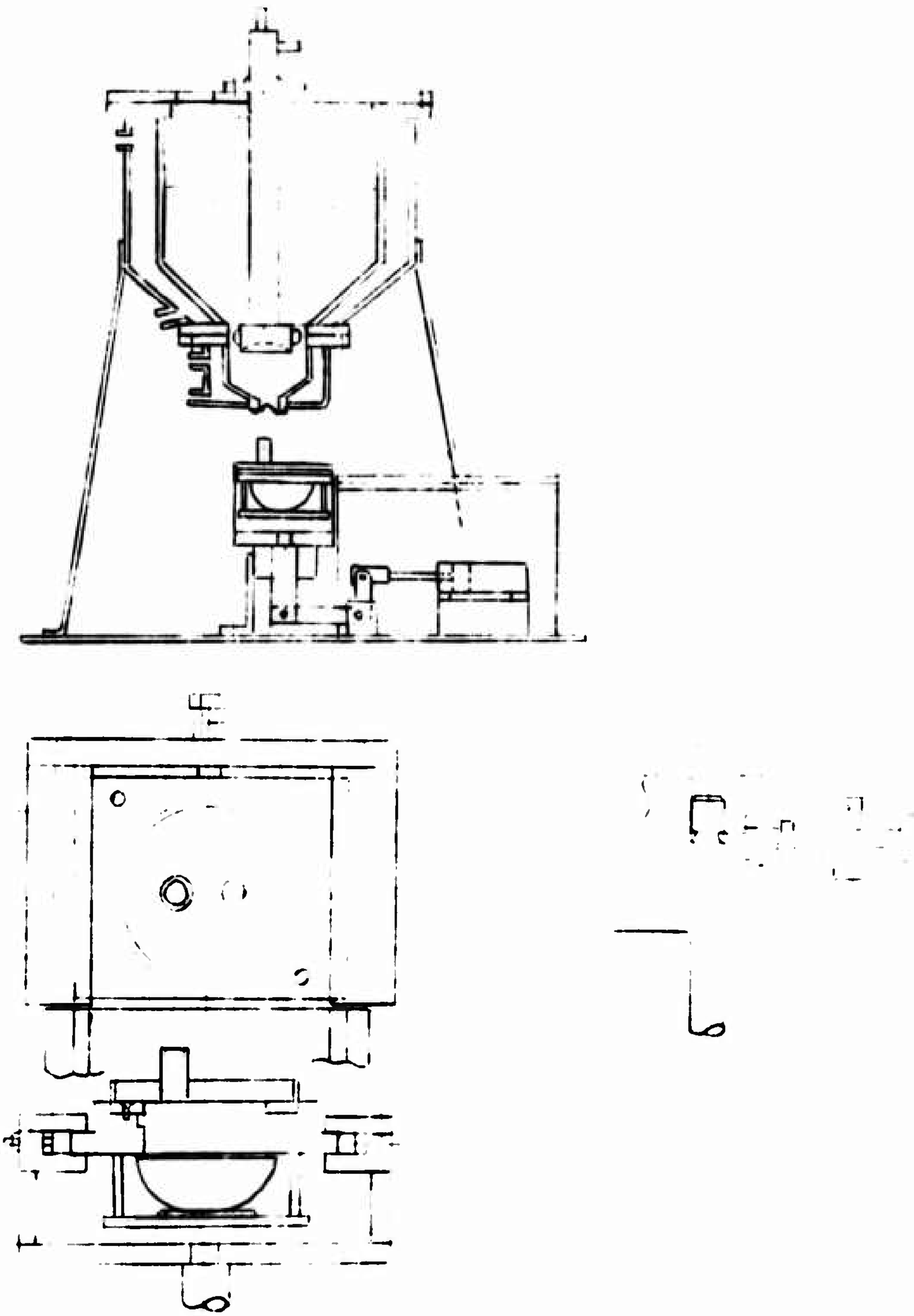
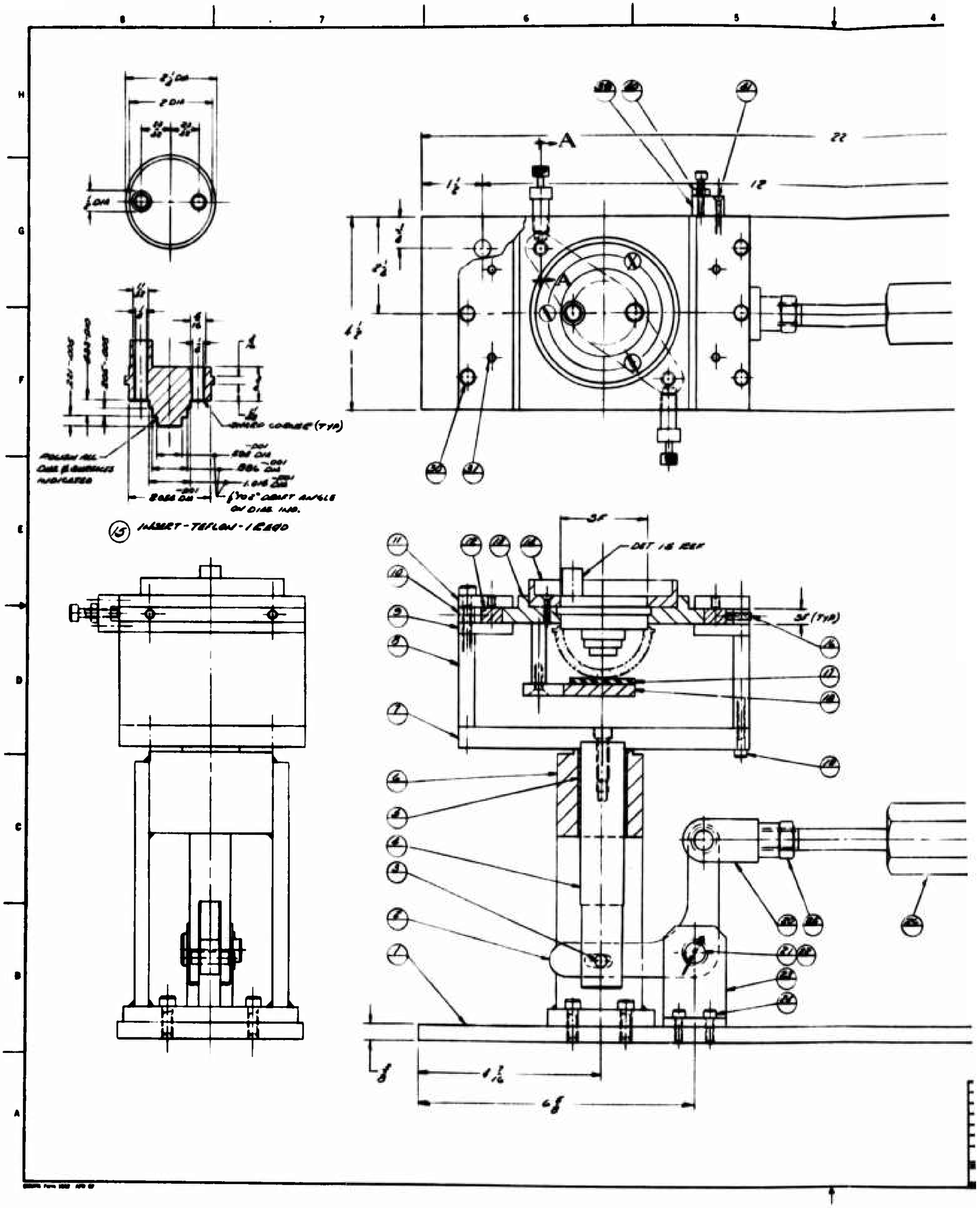
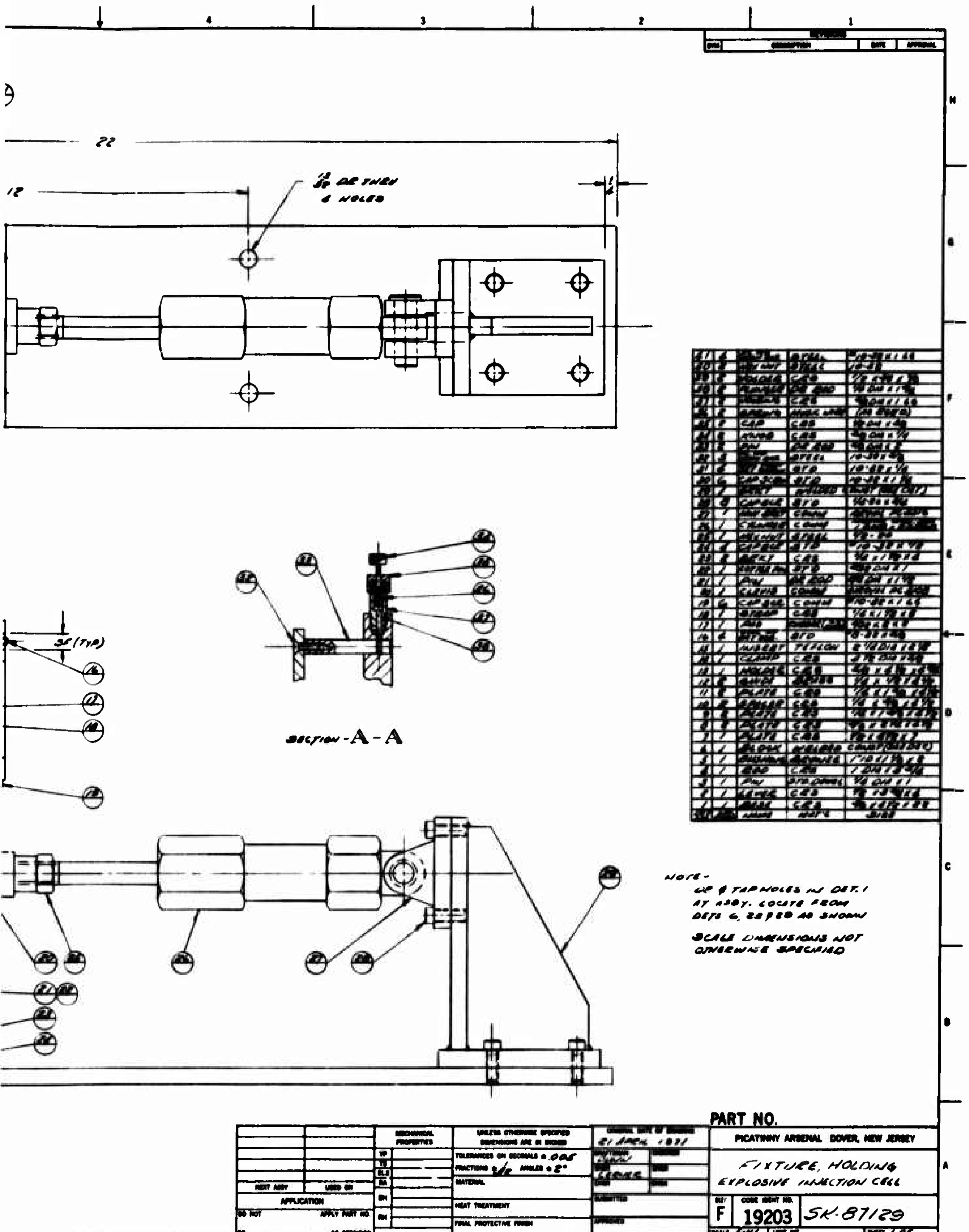


FIGURE 9.

SCHEMATIC OF INJECTION CELL AND HOLDING FIXTURE


A
22
12
DET 16 REF
INSERT - TEFLON - 1 REQD
SHARP CORNER (TYP)



22
12
4 HOLES
SECTION - A - A
35 (TYP)
NOTE -
TAP HOLES IN DET. 1
AT ASSY. LOCATE FROM
DETS 6, 28 & 29 AS SHOWN
SCALE DIMENSIONS NOT
OTHERWISE SPECIFIED
PART NO.
PICATINNY ARSENAL DOVER, NEW JERSEY
FIXTURE, HOLDING
EXPLOSIVE INJECTION CELL
F
19203
SK-87129
APPLICATION
NEXT ASSY
USED ON
MATERIAL
HEAT TREATMENT
FINAL PROTECTIVE FINISH

FIGURE 10

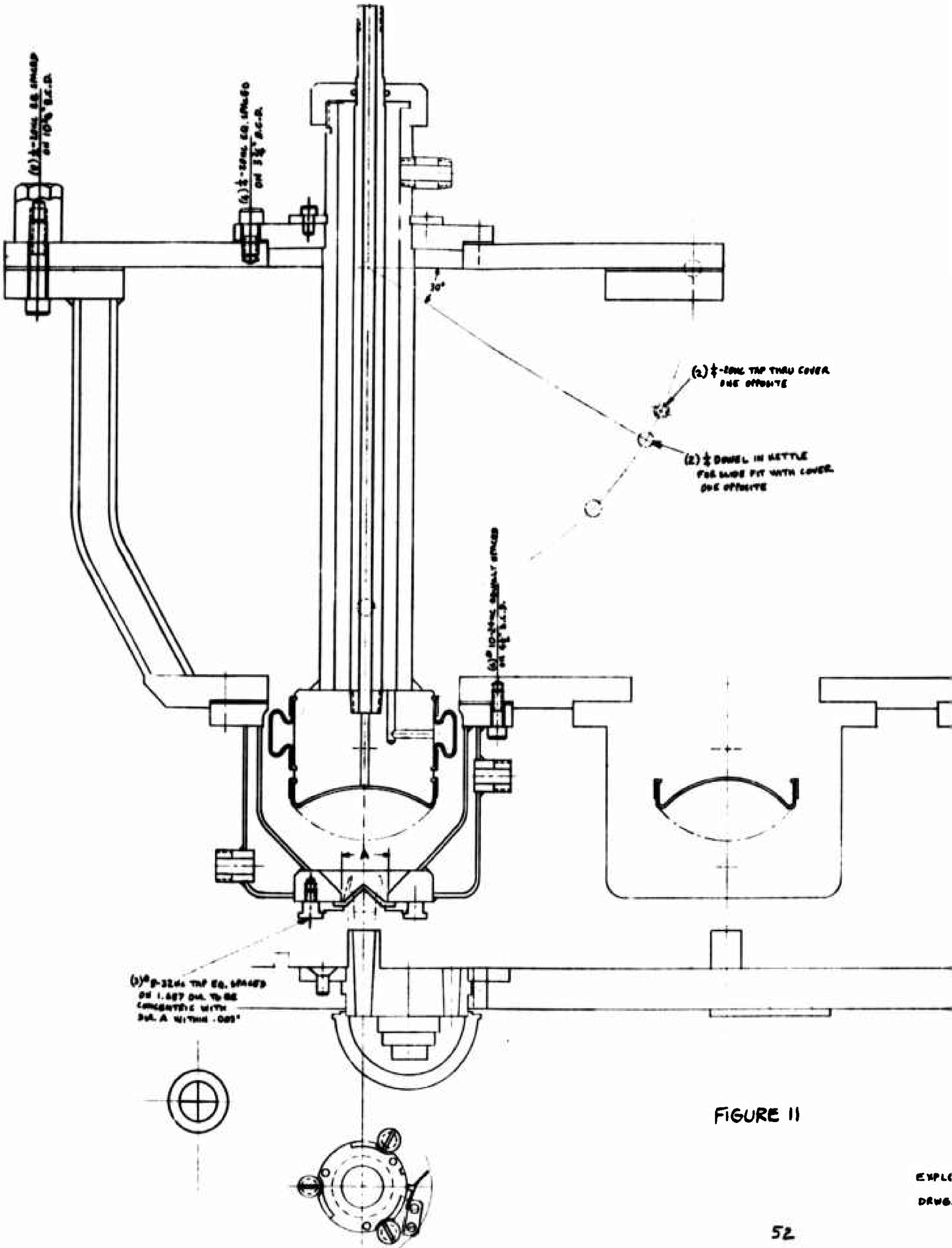

30°
(2) ¼-20NC TAP THRU COVER
ONE OPPOSITE
(2) ¼ DOWEL IN KETTLE
FOR SLIDE FIT WITH COVER
ONE OPPOSITE

FIGURE 11

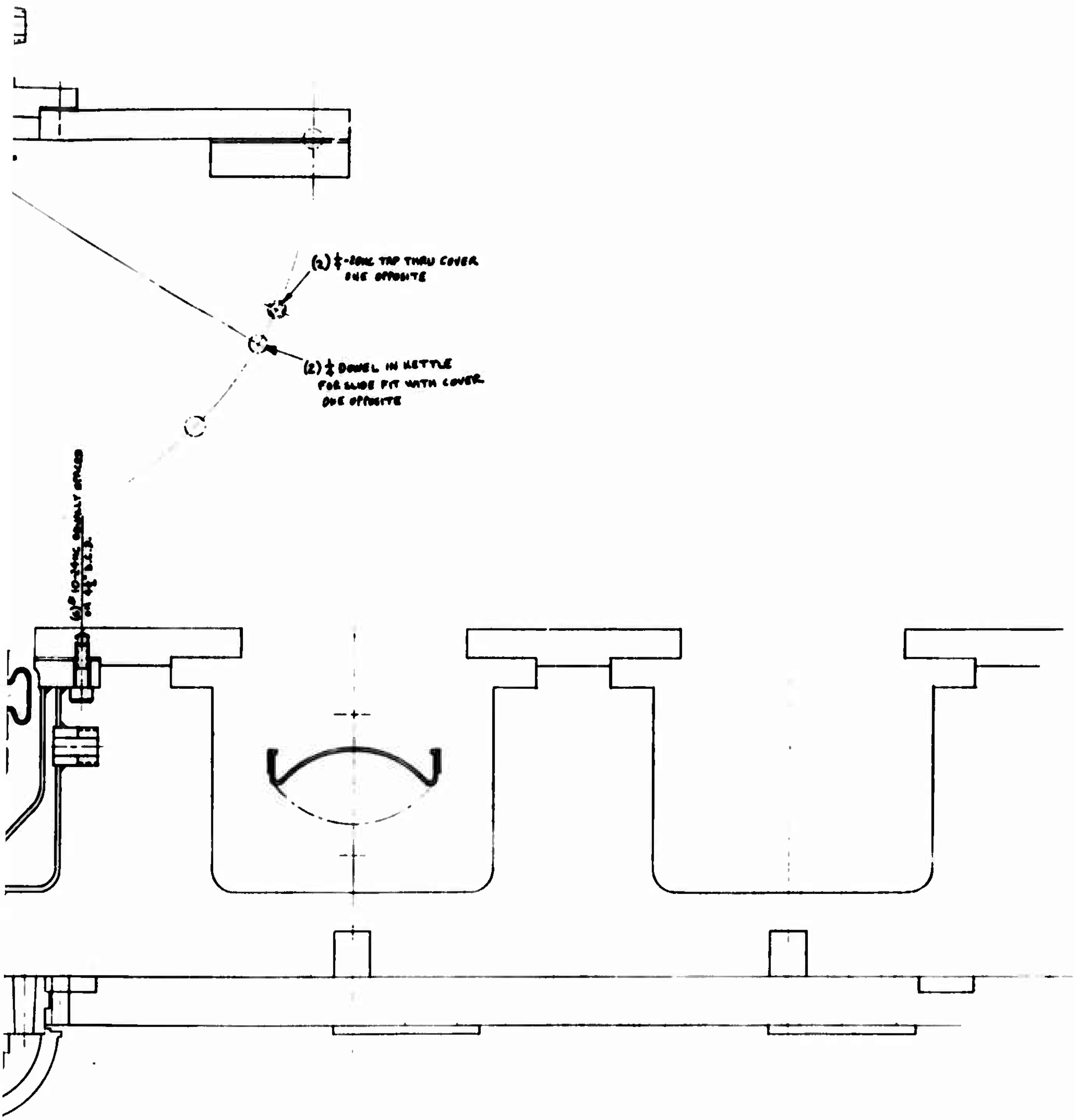
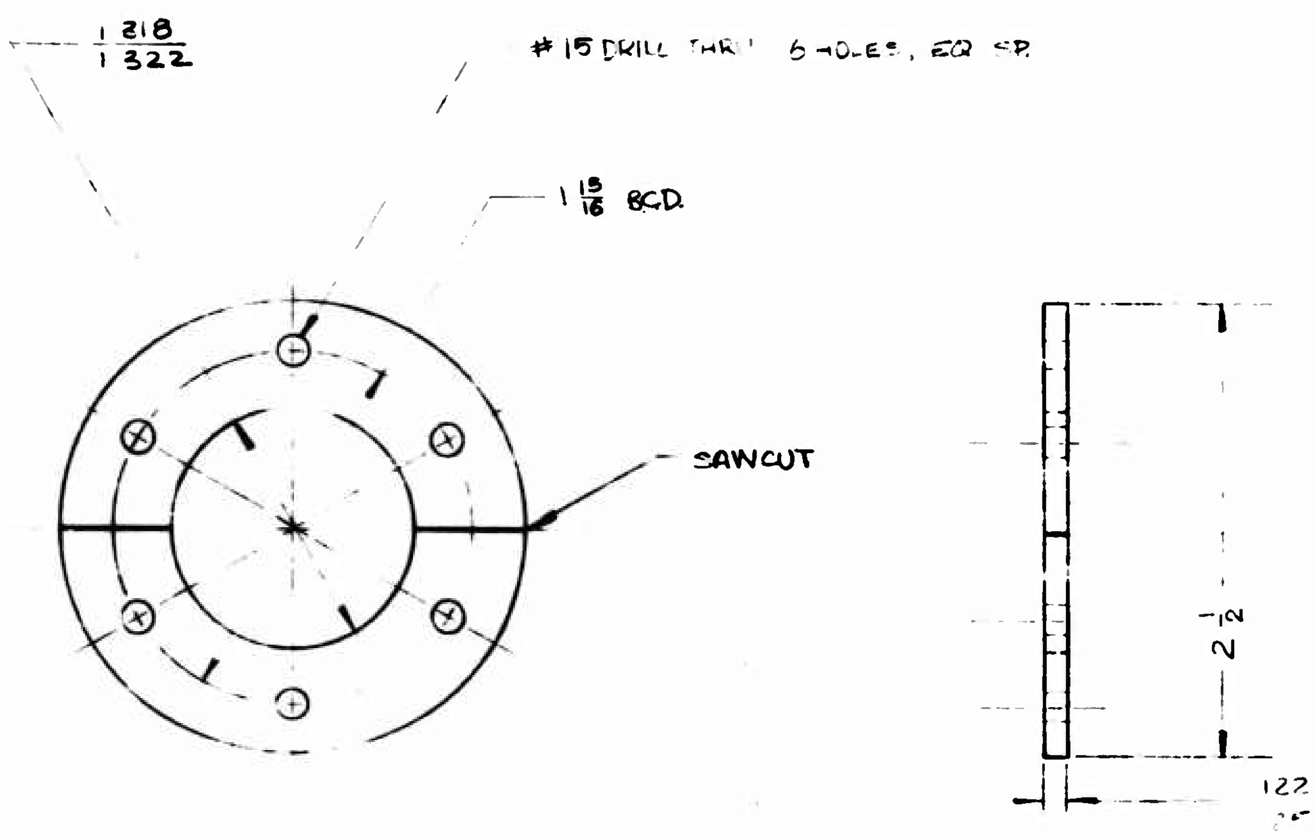


FIGURE 11

EXPLOSIVE INJECTION CELL

DRWG. A.L. SCALE: 1:1 19 JAN 71

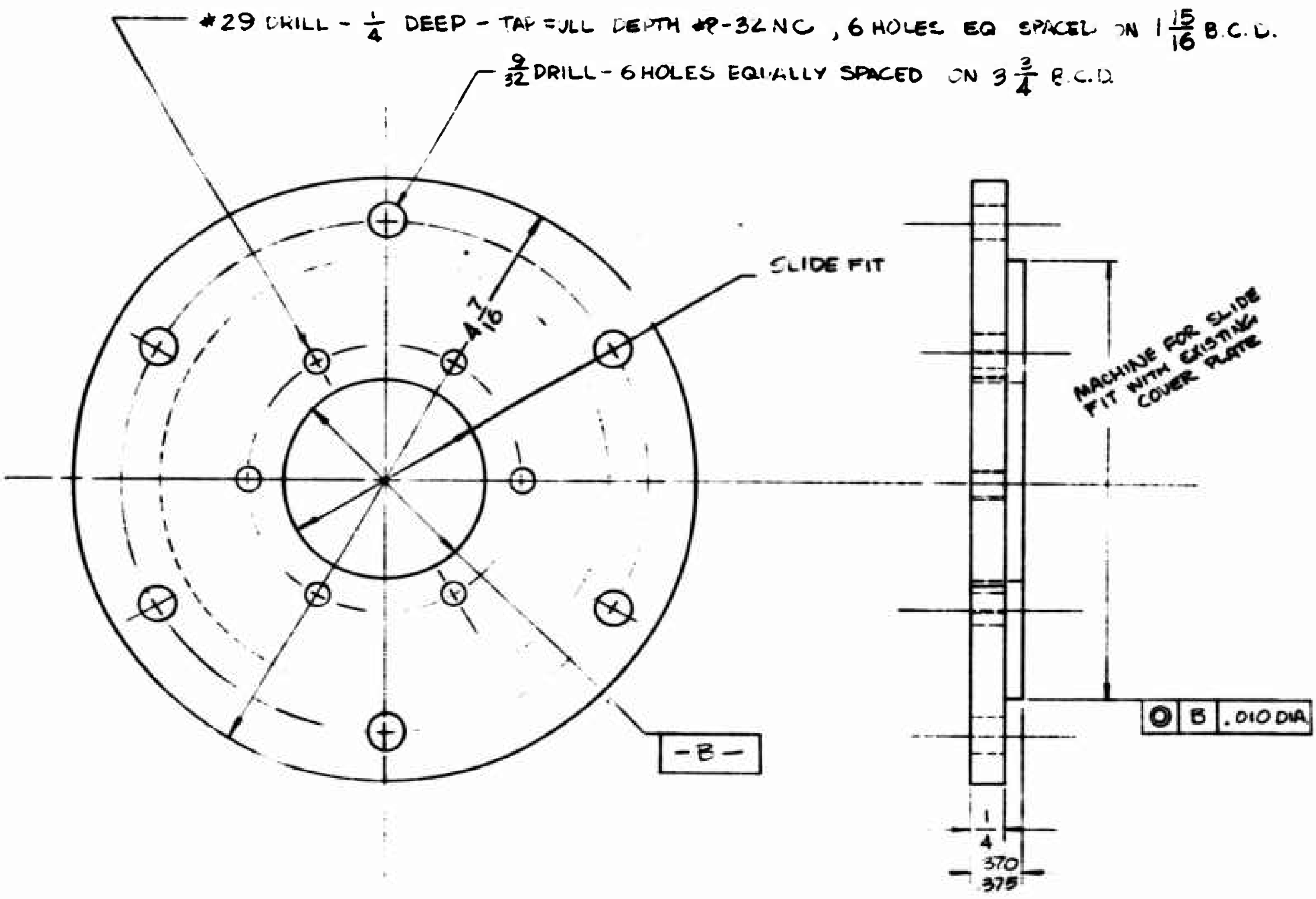


ALL DIMENSIONS BEFORE SAWCUT

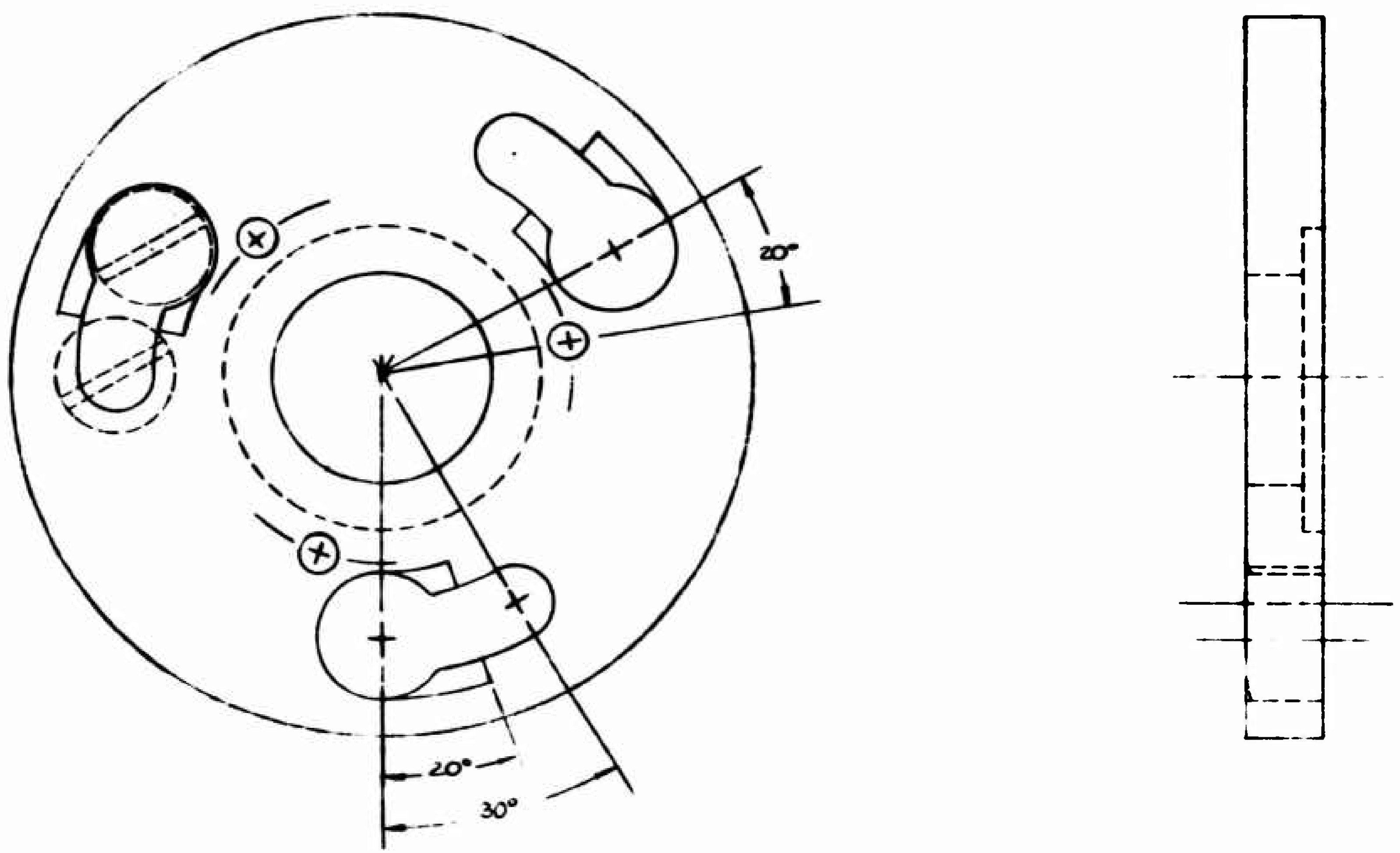
FIGURE 12

DETAILS OF EXPLOSIVE INJECTION CELL

PAGE 1 OF 12

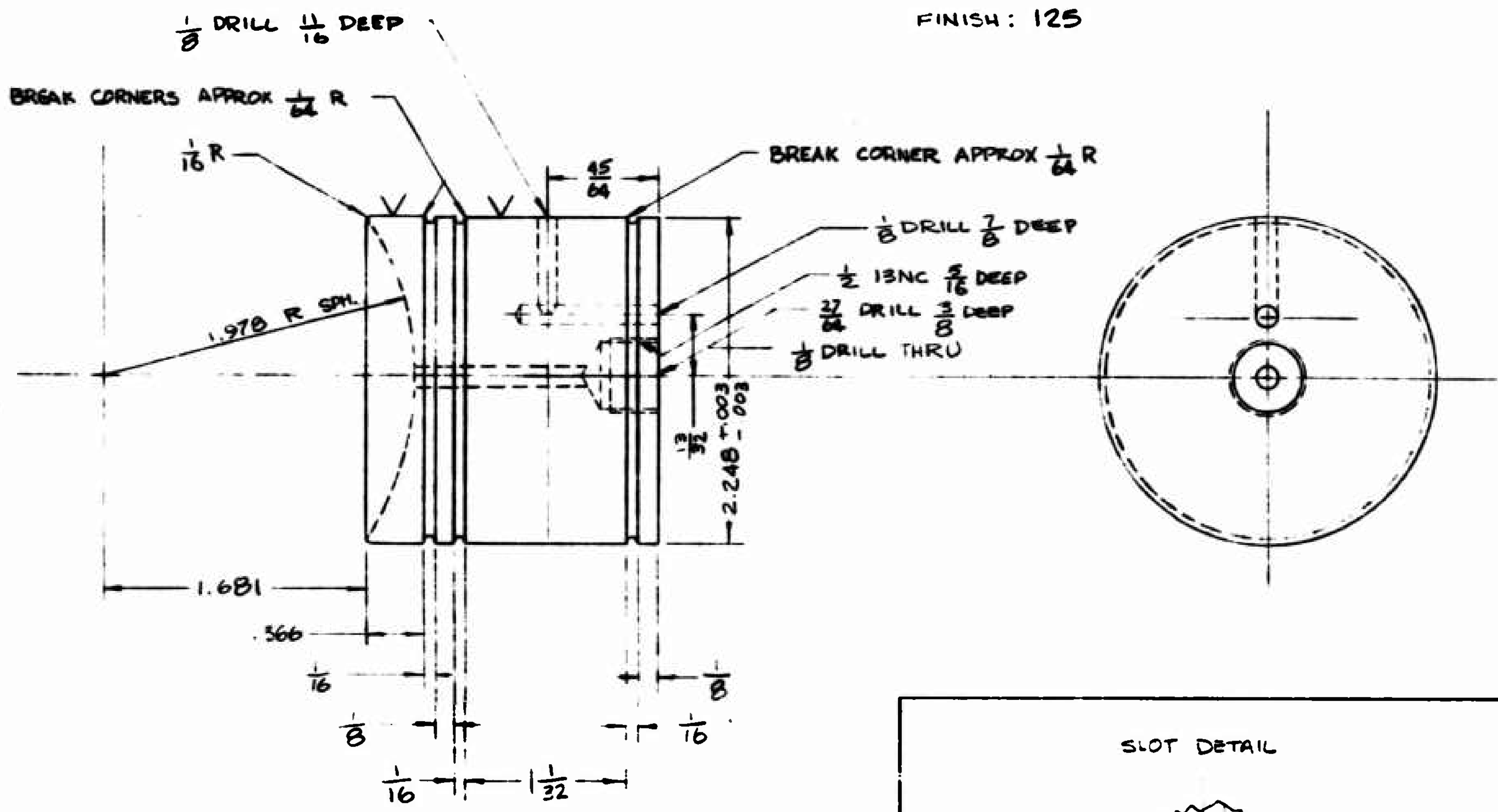


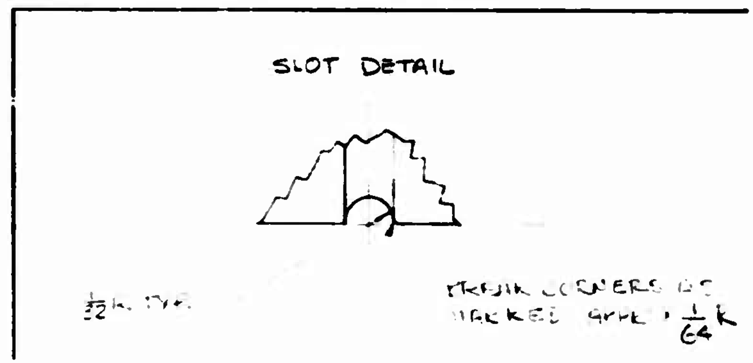
DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 2 OF 12



DETAILS OF EXPLOSIVE INJECTION CELL

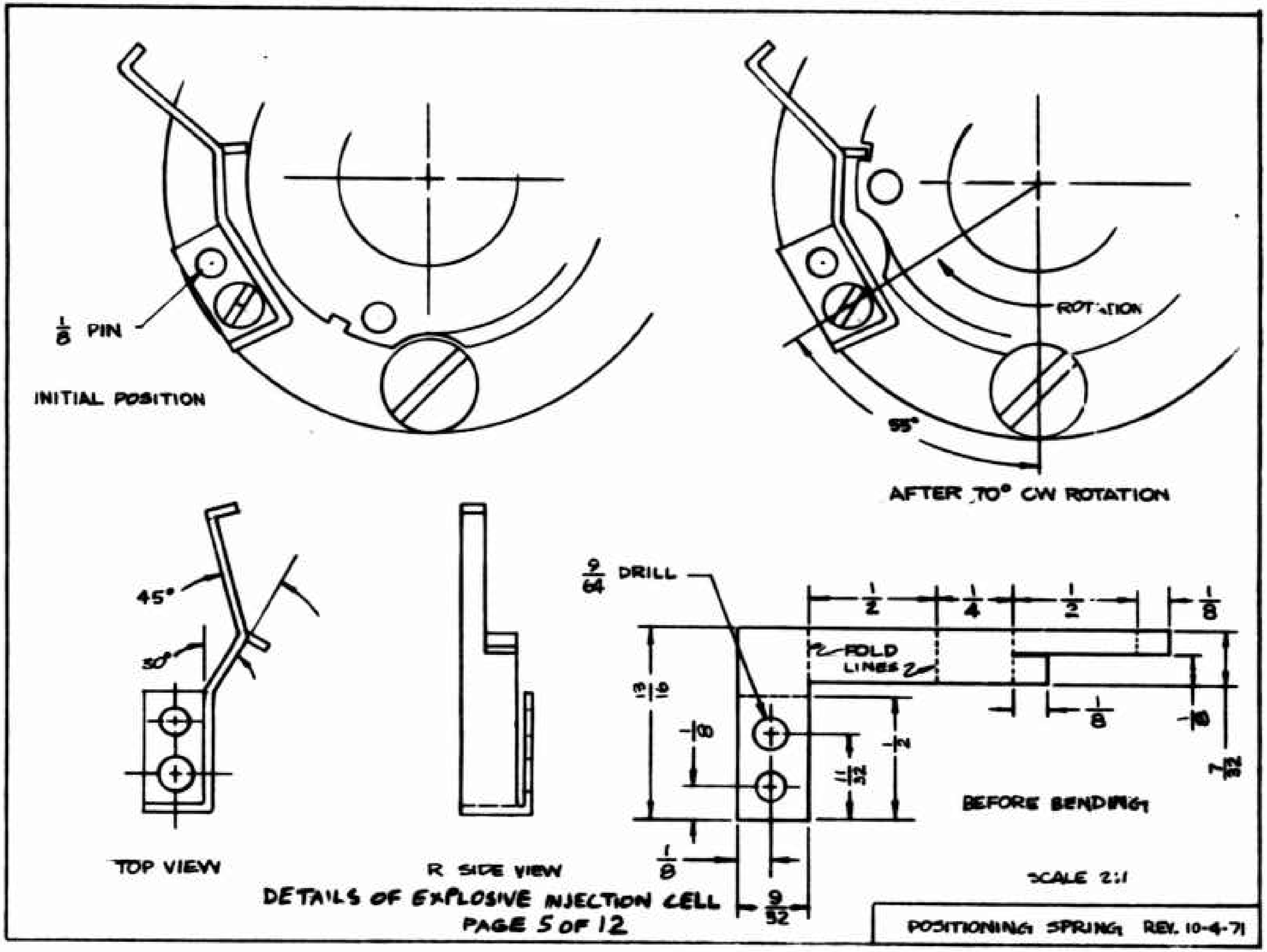
PAGE 3 OF 12



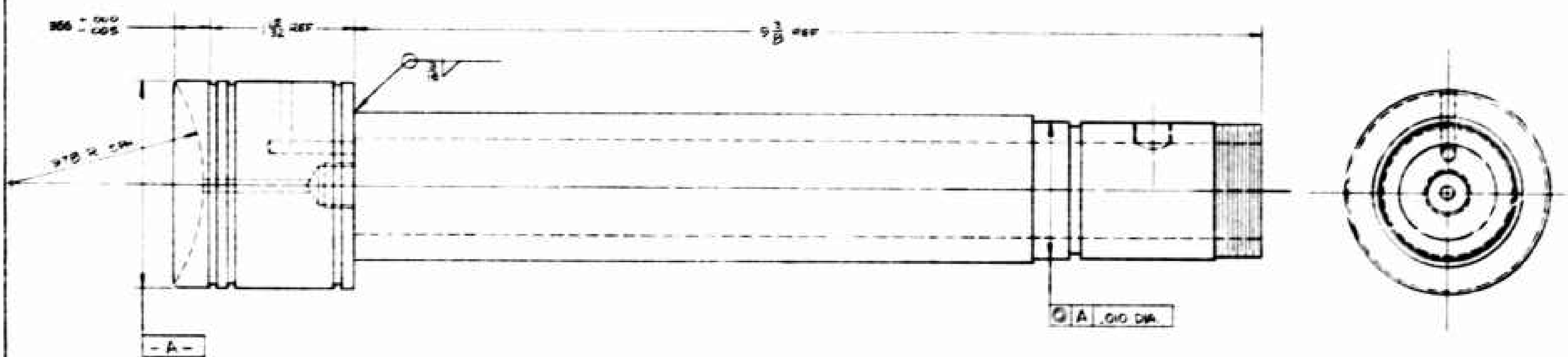


DETAILS OF EXPLOSIVE INJECTION CELL

PAGE 4 OF 12



DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 5 OF 12

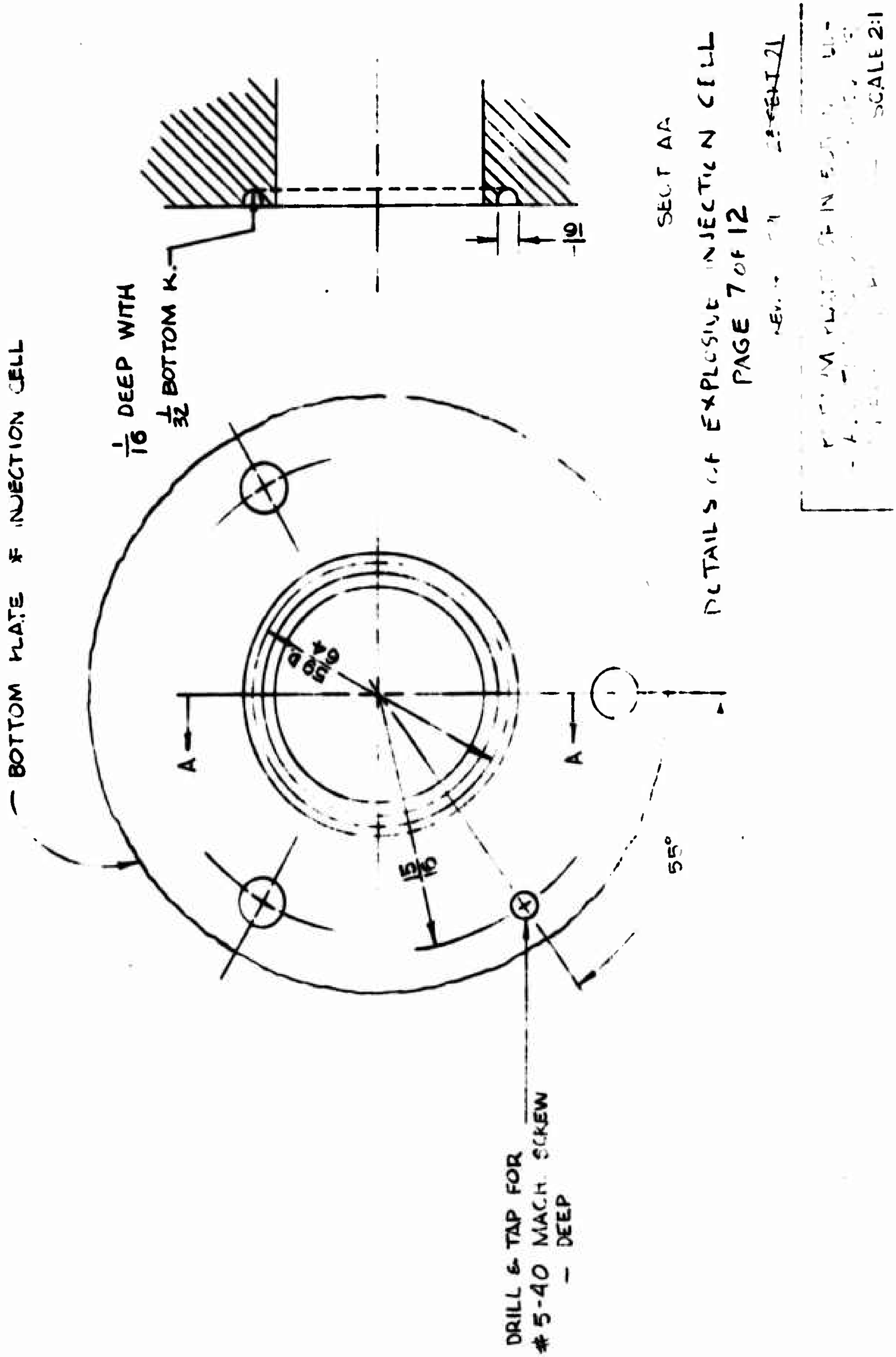


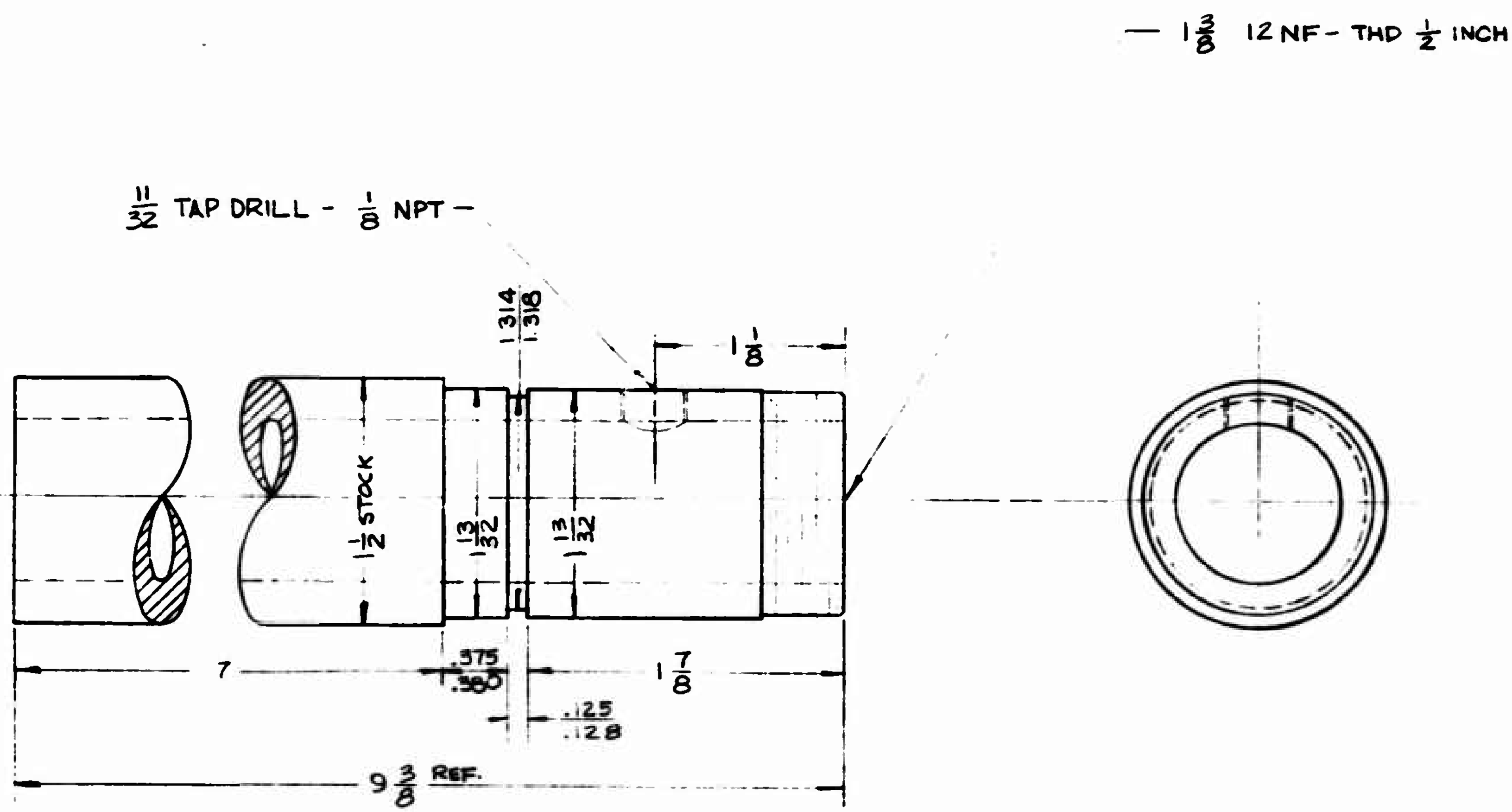
SEE DETAIL DRAWINGS
FOR PART DIMENSIONS

DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 6 OF 12

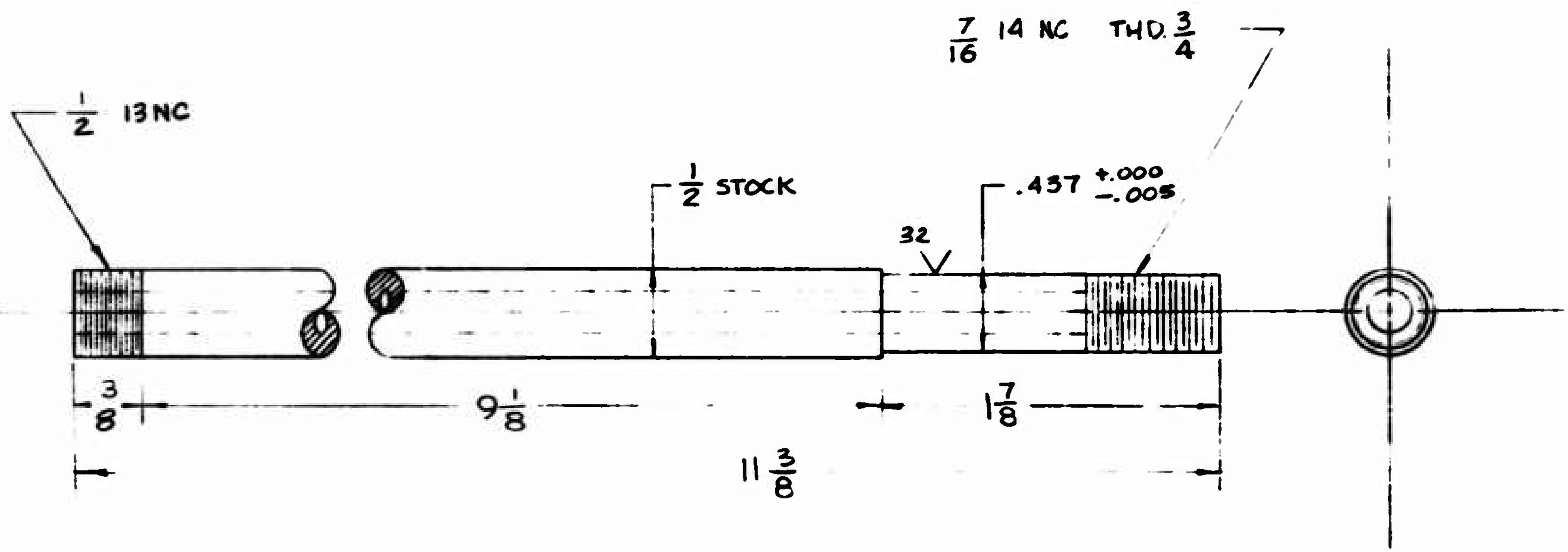
DIAPHRAGM BLOCK & OUTER PIPE ASSY

23-AUG 71

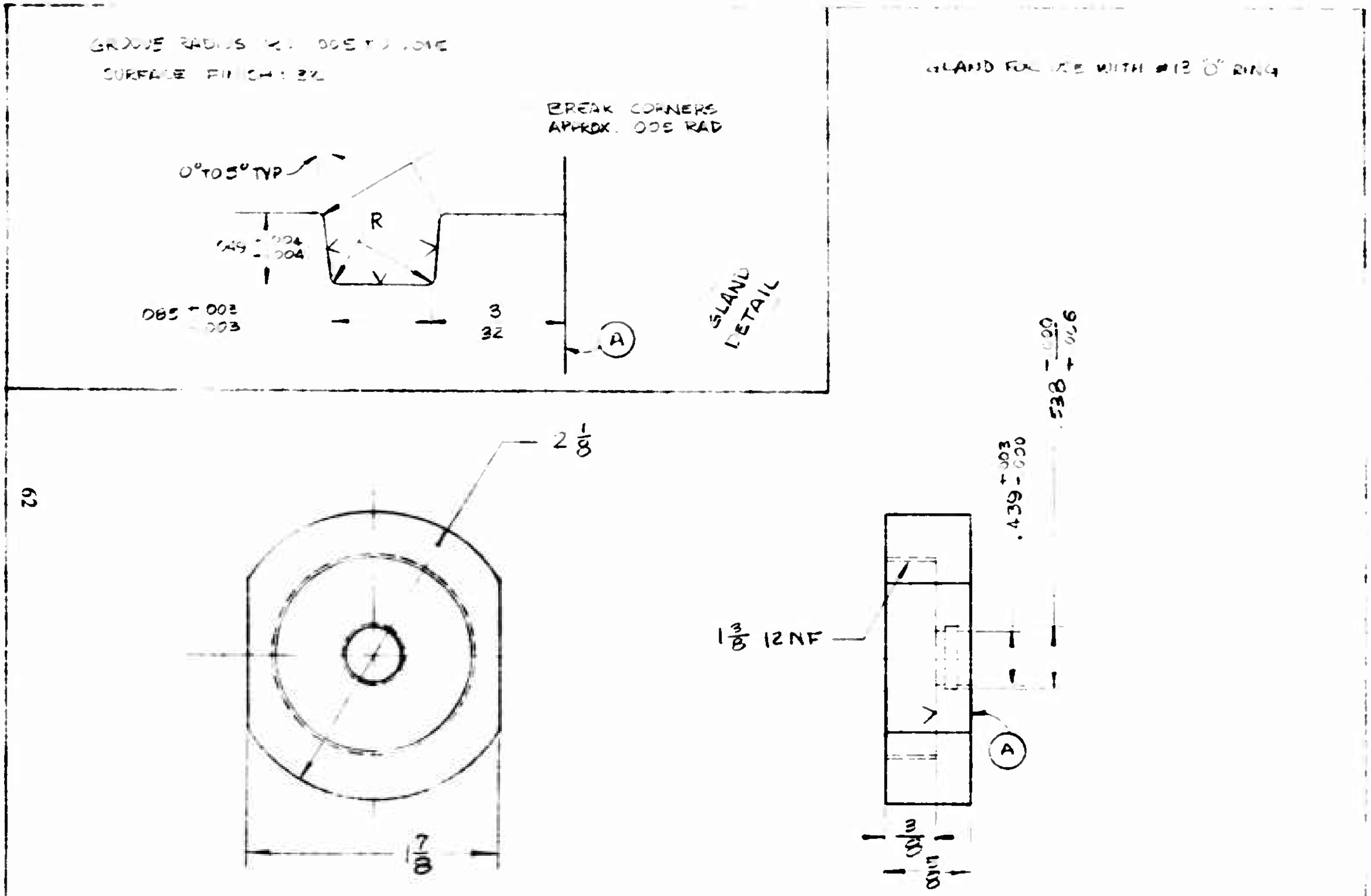

BOTTOM PLATE OF INJECTION CELL
$\frac{1}{16}$ DEEP WITH
$\frac{1}{32}$ BOTTOM R.
SECT AA
DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 7 of 12
SCALE 2:1
A
A
55°
$\frac{15}{16}$
$\frac{59}{64}$ D
$\frac{1}{16}$
DRILL & TAP FOR
5-40 MACH. SCREW
– DEEP



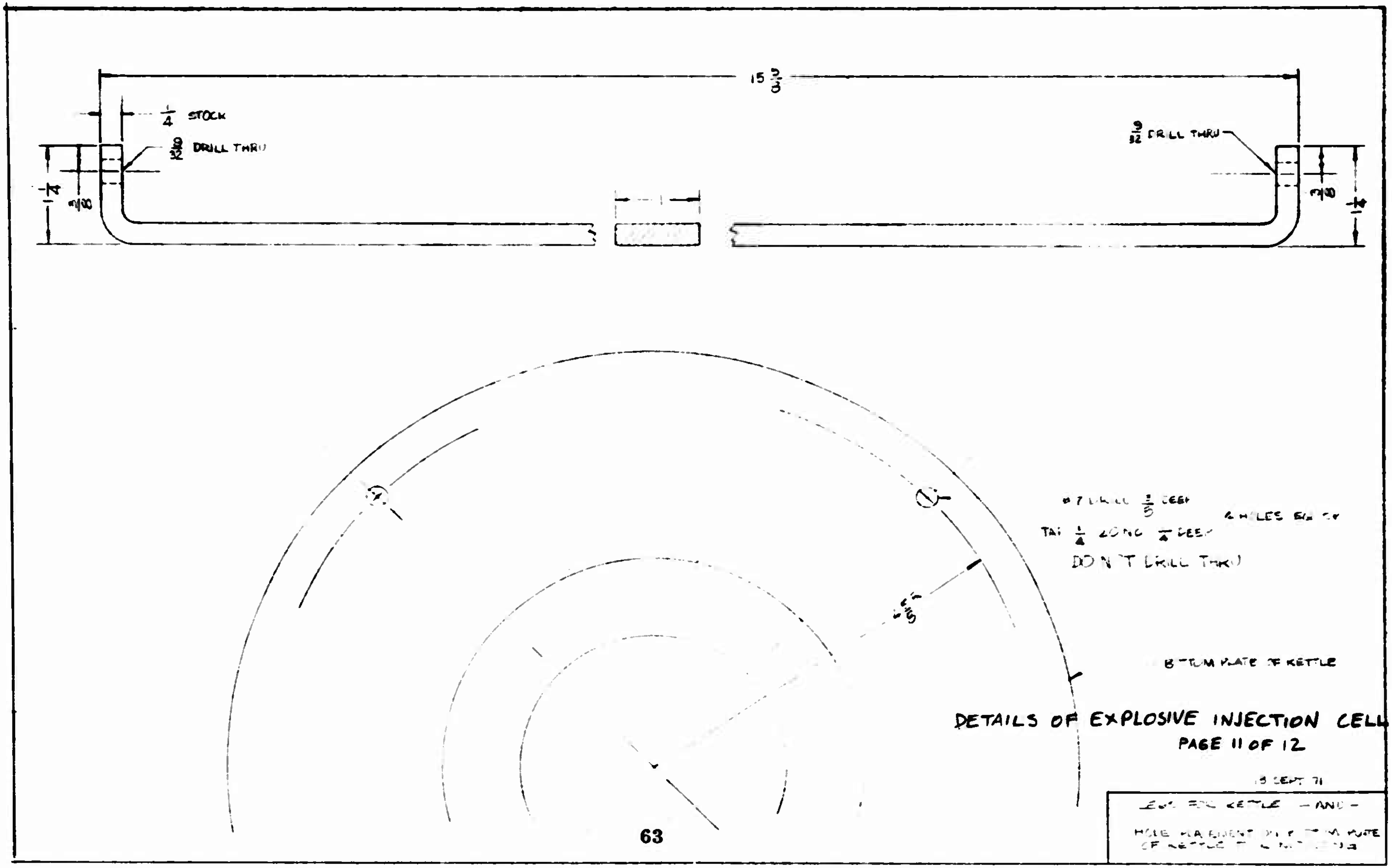
DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 8 OF 12

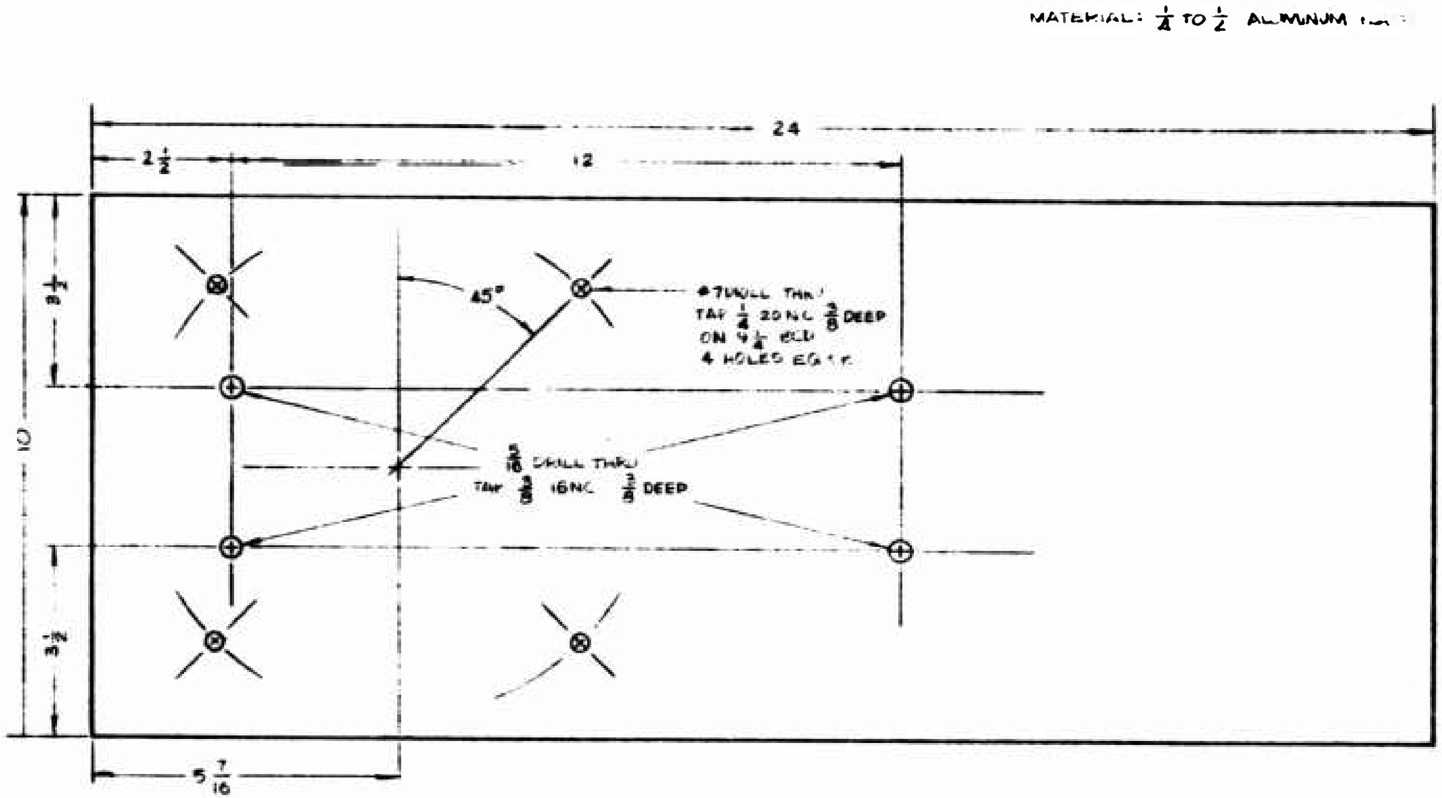


DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 9 OF 12



DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 10 OF 12


15 3/8
1/4 STOCK
9/32 DRILL THRU
9/32 DRILL THRU
DON'T DRILL THRU
DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 11 OF 12



DETAILS OF EXPLOSIVE INJECTION CELL
PAGE 12 OF 12

14 SEPT 71

BASE PLATE LAYOUT FOR MOUNTIN KETTLE & INJECT... CELL ...

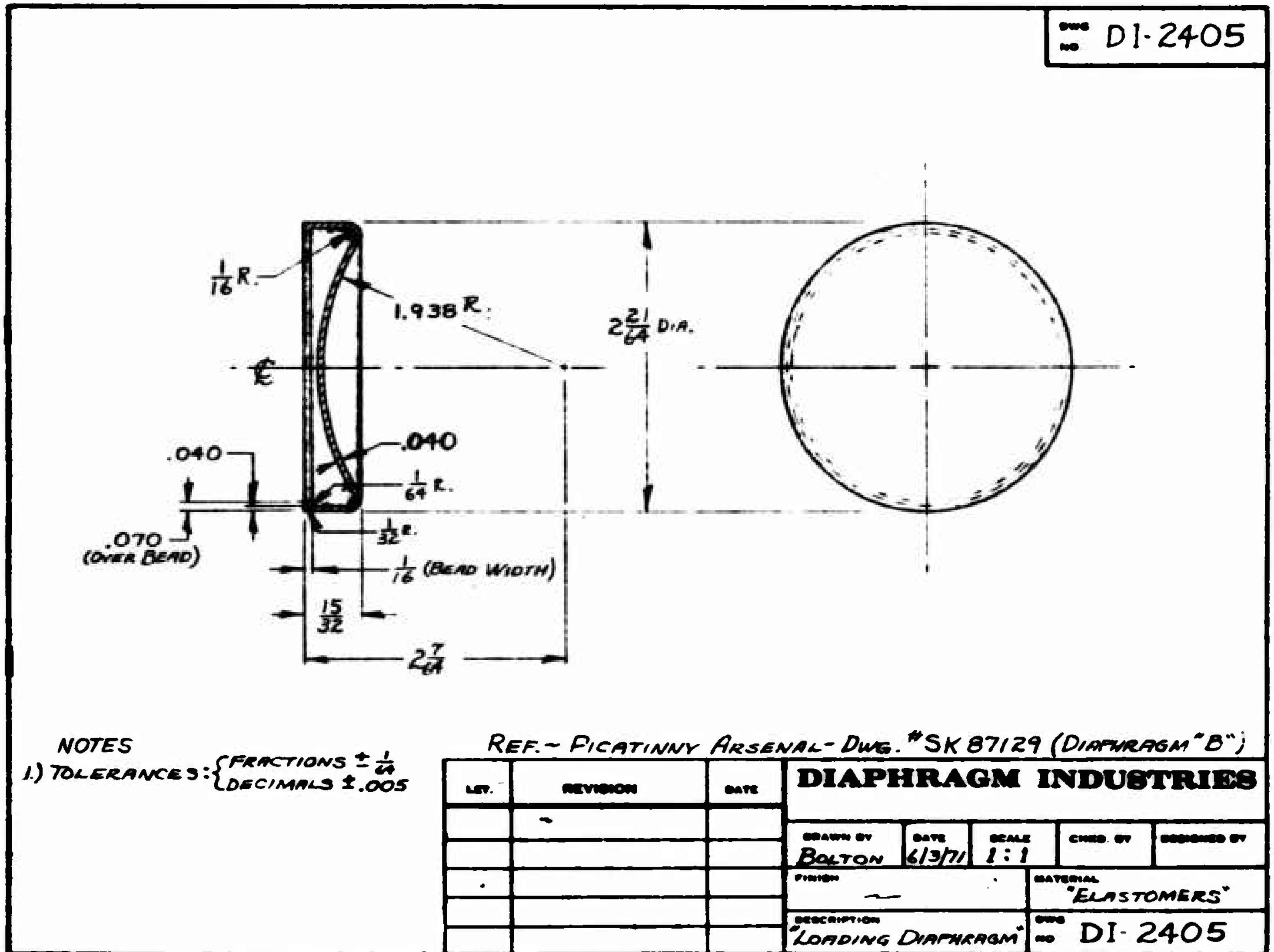


FIGURE 13. PAGE 1 OF 4

JUN 04 1971

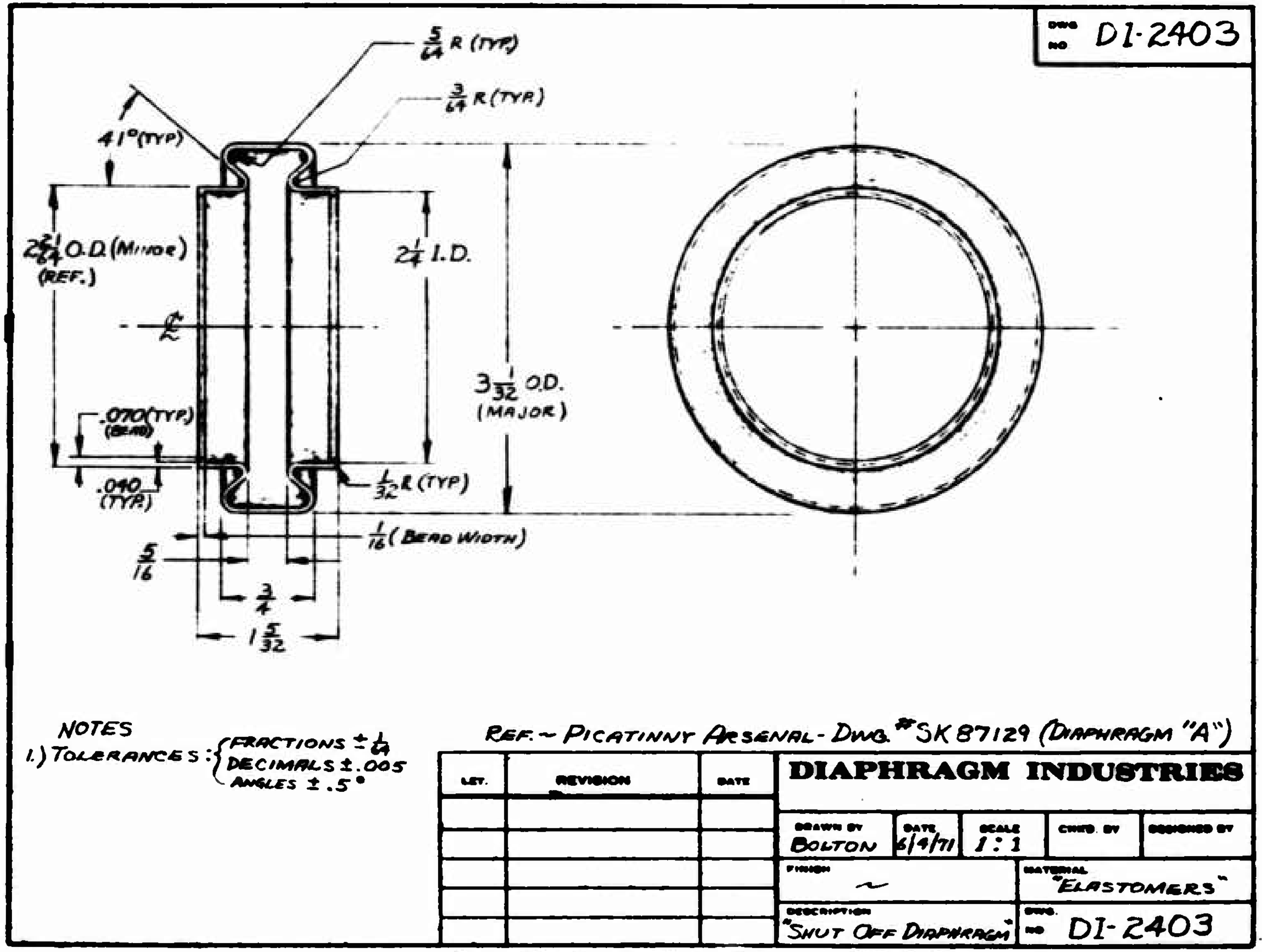


FIGURE 13. PAGE 2 OF 4 JUN 04 1971

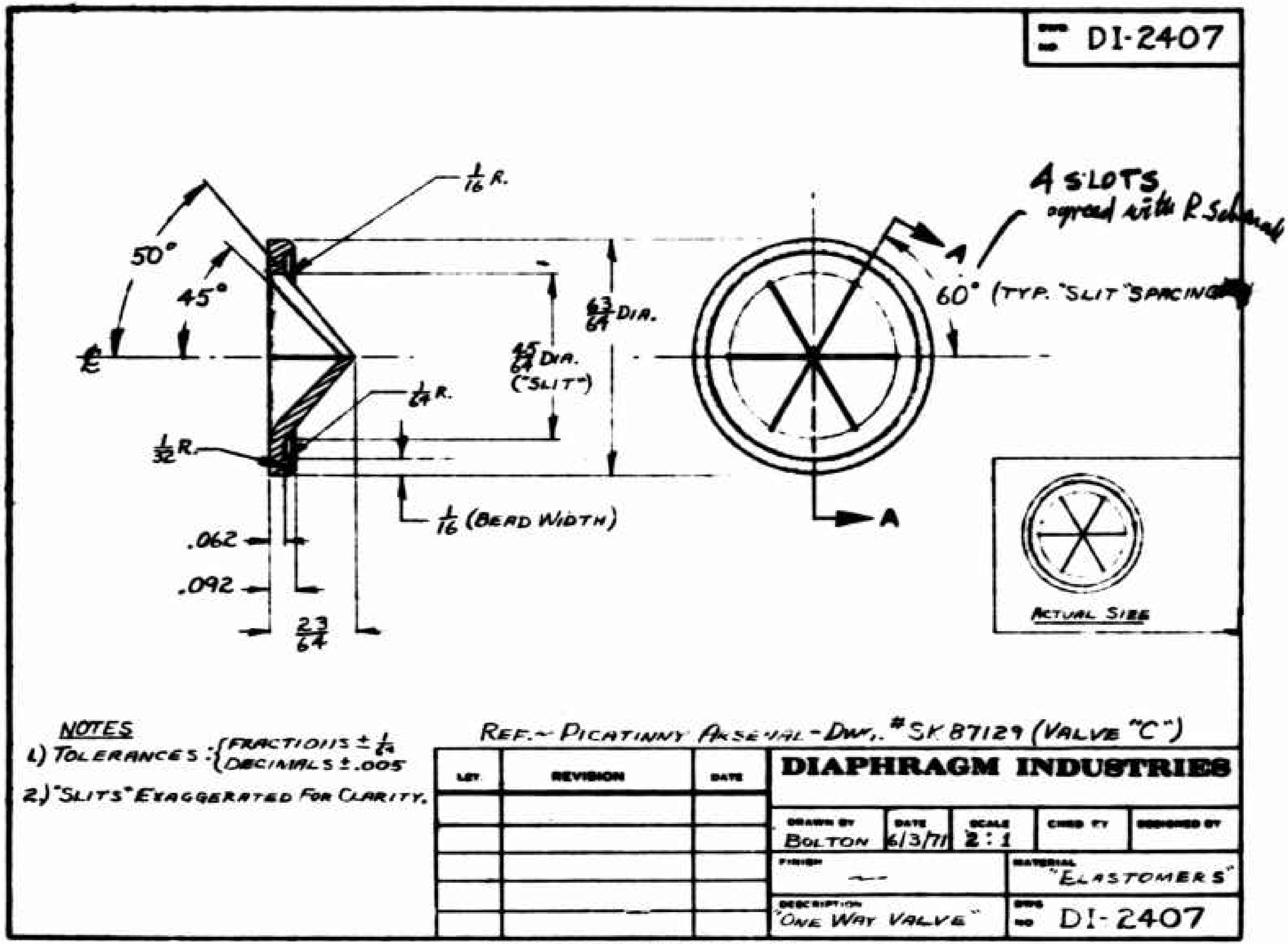
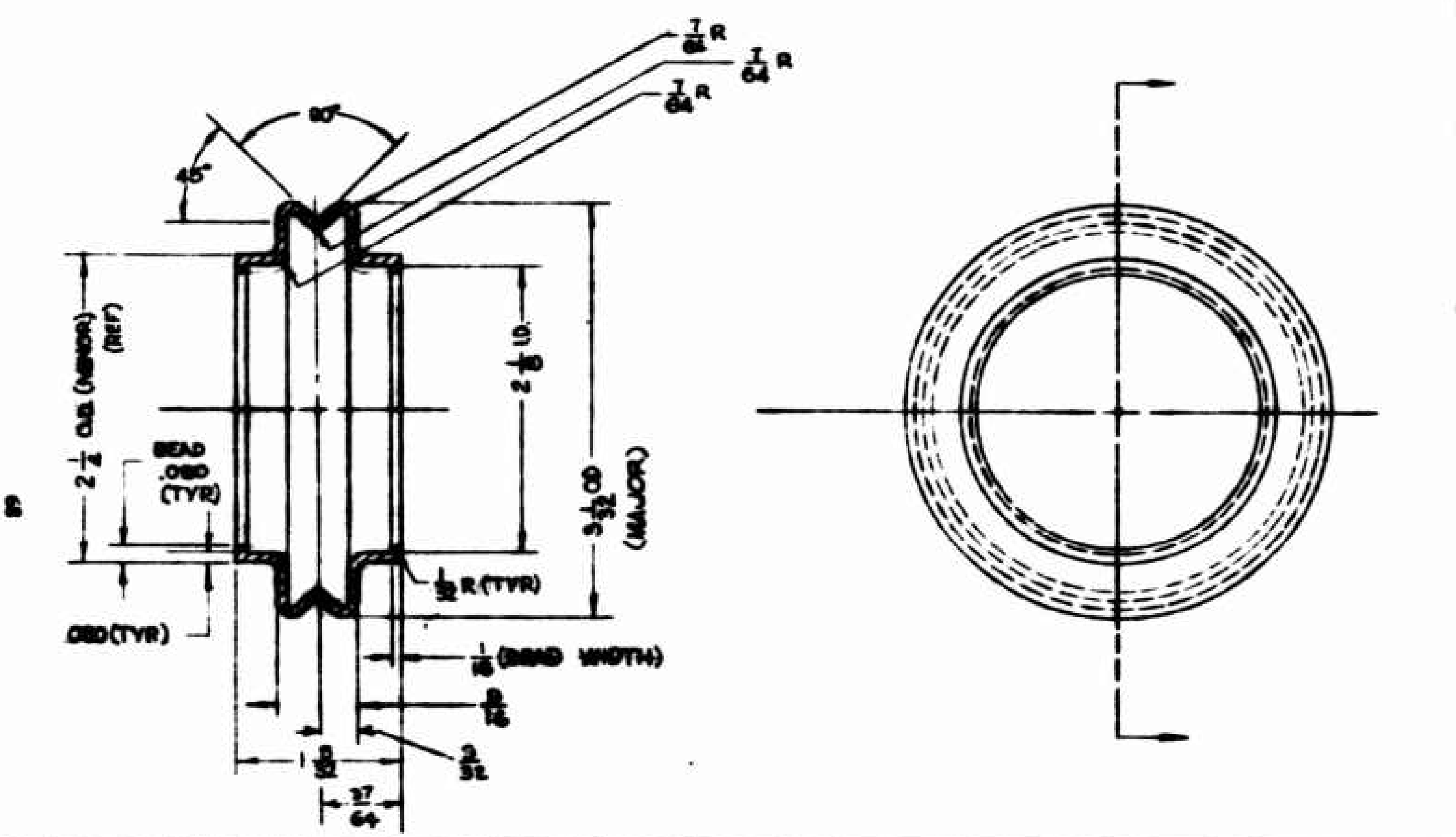


FIGURE 13 PAGE 3 OF 4 JUN 03 1971



TOLERANCES: FRACTIONS $\pm\frac{1}{64}$ DECIMALS $\pm$ .005 ANGLES $\pm$ 0.5°	DWG NO. - SK 87132 SCALE 1:1 MATERIAL : ELASTOMERS DRAWN BY: SJB	PROPOSED **SHUT OFF DIAPHRAGM** RAPAD - AUTOMATION SECTION MANUFACTURING TECHNOLOGY DIR. ENGR: A. LERNER 12-2-71

FIGURE 13. PAGE 4 OF 4

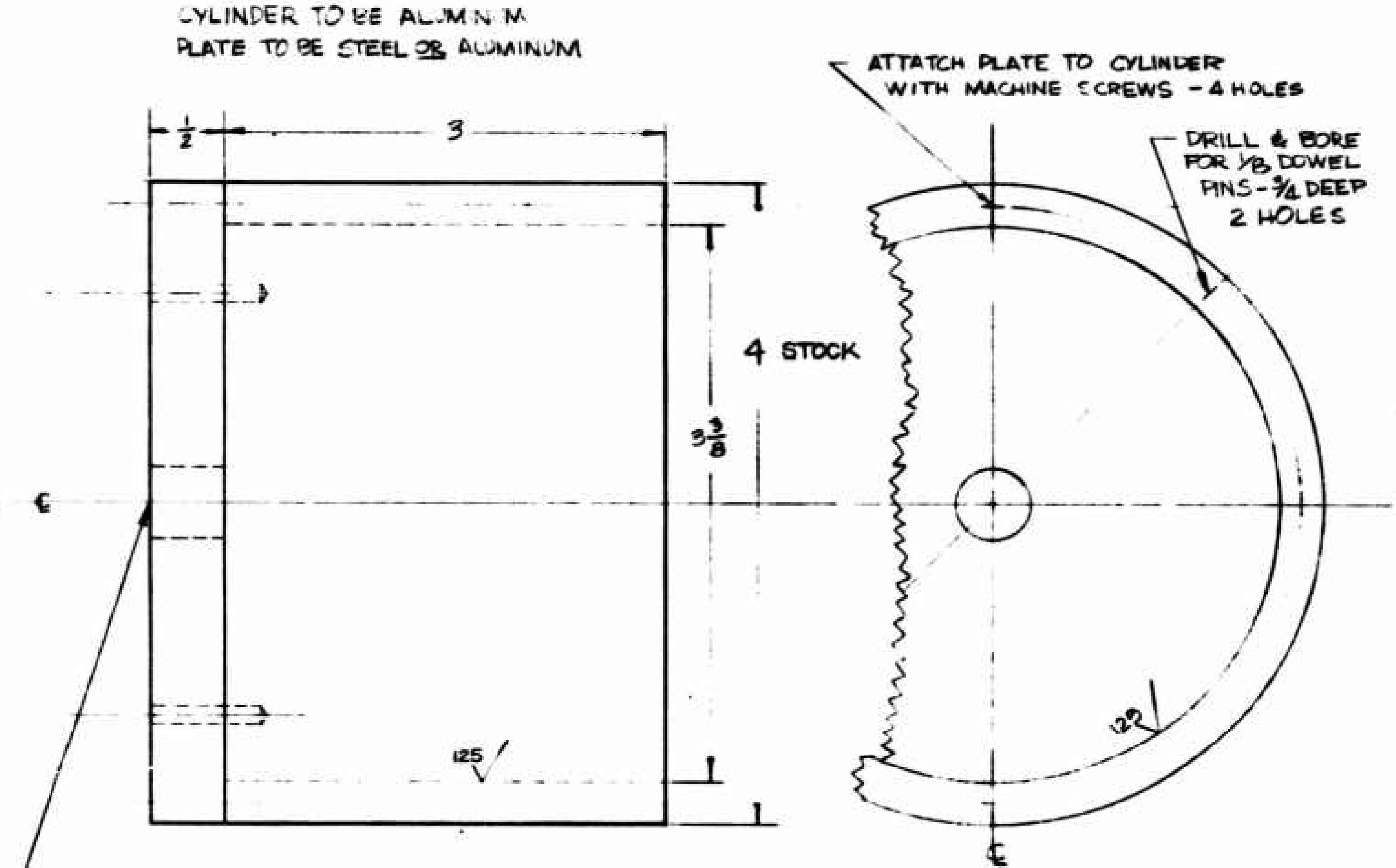
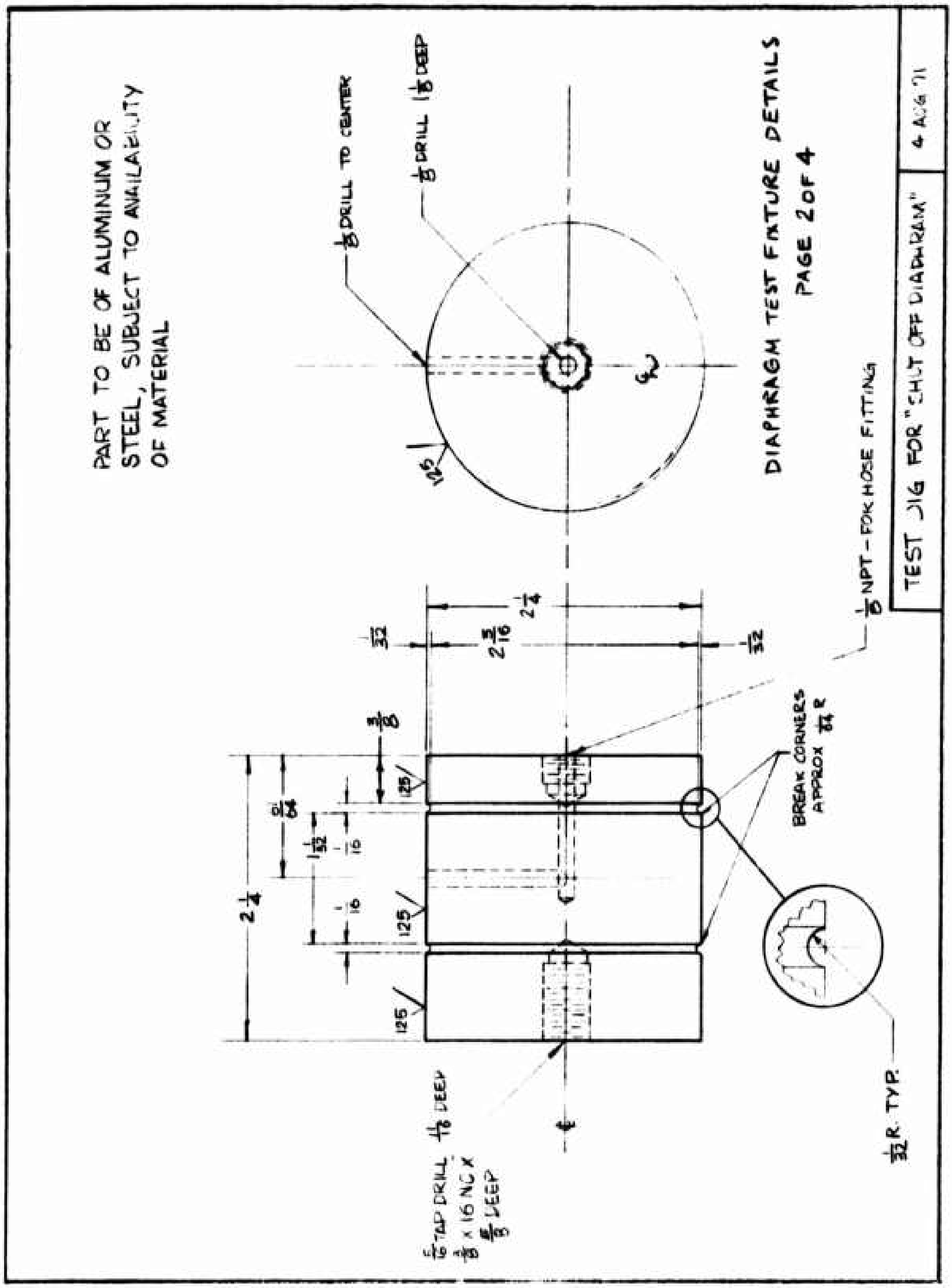
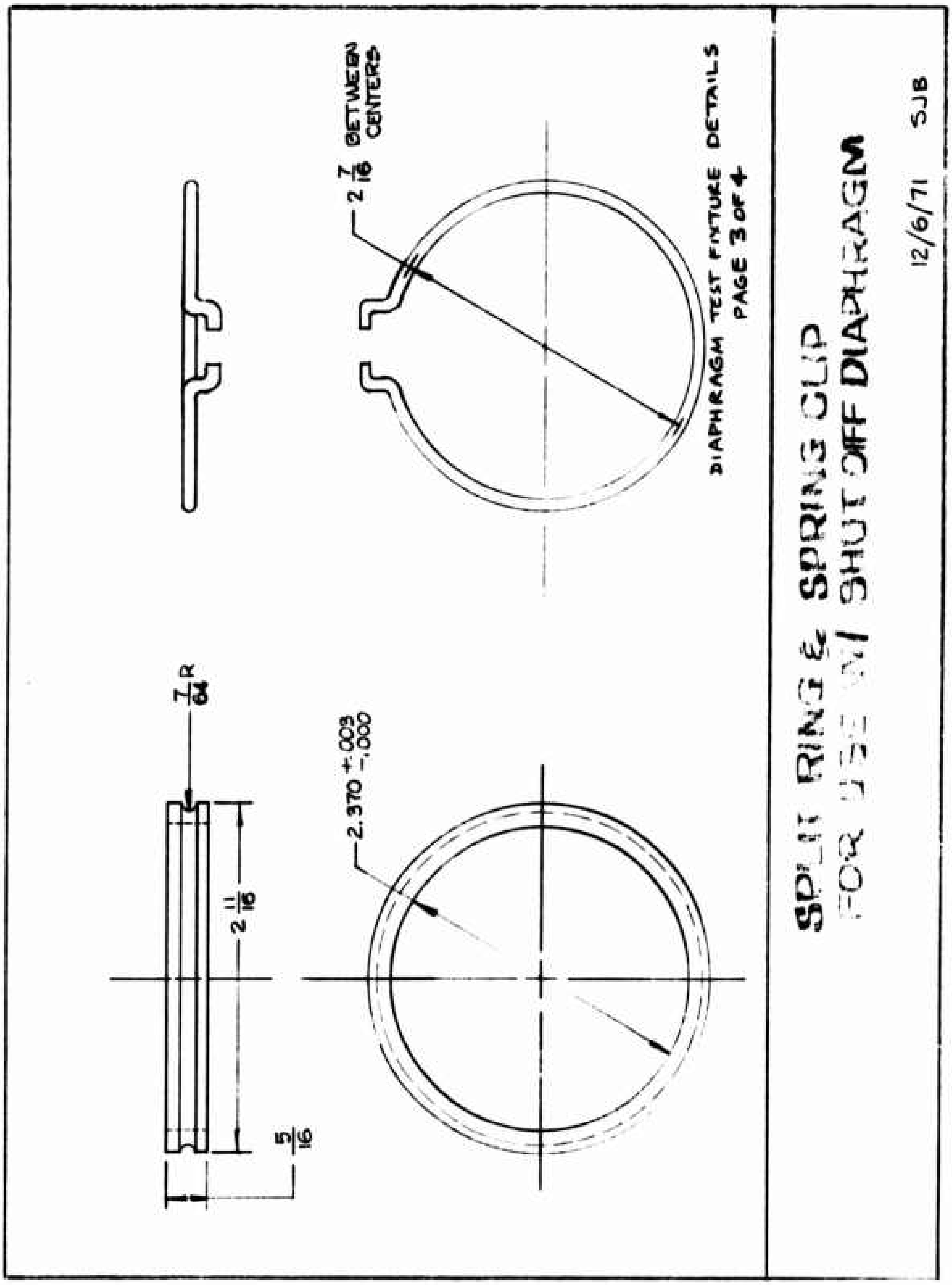


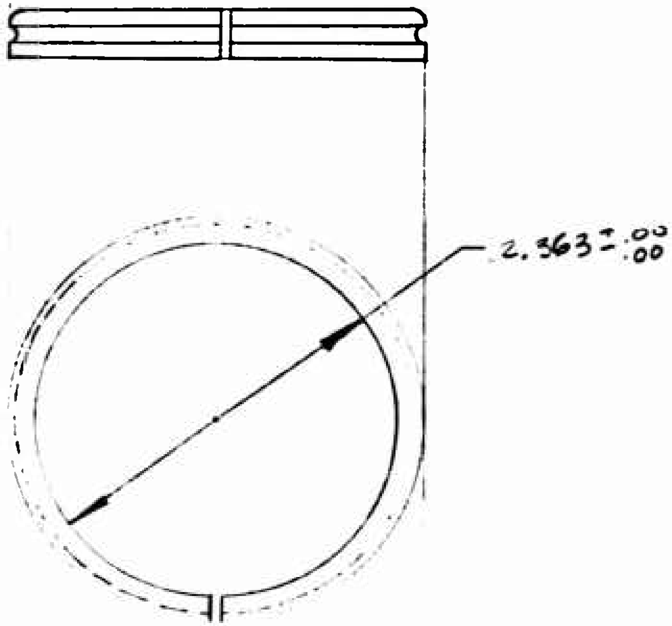
FIGURE 14.
DIAPHRAGM TEST FIXTURE DETAILS
PAGE 1 OF 4

TEST JIG FOR 'SHUT OFF DIAPHRAM'	4 AUG 71


PART TO BE OF ALUMINUM OR STEEL, SUBJECT TO AVAILABILITY OF MATERIAL
1/8 DRILL TO CENTER
1/8 DRILL 1 1/8 DEEP
125
DIAPHRAGM TEST FIXTURE DETAILS
PAGE 2 OF 4
TEST JIG FOR "SHUT OFF DIAPHRAGM"
4 AUG 71
1/8 NPT - FOR HOSE FITTING
BREAK CORNERS APPROX 1/64 R
1/32 R TYP.
5/16 TAP DRILL 3/8 x 16 NC x 5/8 DEEP
2 1/4
2 3/16
1/32
3/8



SPLIT RING & SPRING CLIP
FOR USE W/ SHUT OFF DIAPHRAGM
12/6/71 SJB
DIAPHRAGM TEST FIXTURE DETAILS
PAGE 3 OF 4
2 7/16 BETWEEN CENTERS
2.370 +.003 -.000
7/64 R
2 11/16
5/16



SKETCH- SPLIT RING FOR
SECURING SHUT OFF DIAPHRAGM
TO DIAPHRAGM BLOCK

MATERIAL - NYLON OR TEFLON

DIAPHRAGM TEST FIXTURE DETAILS
PAGE 4 OF 4